



EIS 824

AB019558

Northparkes Project, Peko-Wallsend Operations Limited, Final  
Environmental impact statement. V.2 Appendices.

# **NORTHPARKES PROJECT**

**PEKO-WALLSEND OPERATIONS LTD**

NSW DEPT PRIMARY INDUSTRIES



AB019558

## **ENVIRONMENTAL IMPACT STATEMENT APPENDICES**

**AUGUST 1990**

EIS  
824  
Vol 2

NSW DEPARTMENT OF  
MINERALS AND ENERGY

21 FEB 1991

LIBRARY

**Peko-Wallsend Operations Limited**

# Northparkes Project

Final

## Environmental Impact Statement

*Volume 2*  
*APPENDICES*

NSR Environmental Consultants Pty Ltd  
25 Burwood Road,  
Hawthorn,  
Victoria,  
3122

In association with:  
Stuart Miller & Associates Pty Ltd  
Challis & Associates Pty Ltd  
ANU Archaeological Consultancies  
Mitchell McCotter & Associates Pty Ltd

CR: 433  
August 1990

## CONTENTS

A	Land Use Study
B	Environmental Water Study
C	Climatic Data for Parkes
D	Bird Habitat Management
E	Archaeological Survey
F	Waste Rock and Tailings Geochemistry Testwork
G	Mine Area Soil Survey
H	Noise Investigation
I	Dust Dispersion Modelling
J	Dust Gauge Siting
K	Controlling Blast-generated Ground Vibrations, Air Vibrations, Flyrock and Dust
L	Examples of Dust Gauge Siting and Servicing Records
M	Social and Physical Infrastructure
N	Cyanidation Tailings Characterisation
O	Technical Memoranda: (i) Dust generation - Mining Activities (ii) Blasting Impact - Revised Calculations
P	Radiotelescope Interference Study
Q	Ground Vibrations Produced by Underground Blasts
R	Bogan Road Traffic Analysis
S	Overview Report of the Commission of Inquiry Re Section 94
T	Mine-Derived Dust Increments
U	Site Water Management Scheme

**APPENDIX A**

**LAND USE STUDY**

R. Jones  
Geopeko, Parkes, N.S.W.  
March 1986.

LAND USE STUDY

By Roger Jones

PARKES N.S.W.

MARCH 1986

## CONTENTS

	<u>Page No.</u>
1. INTRODUCTION	1
1.1 Definition of Areal Terms	1
1.1.1 Central Slopes Statistical Agricultural Area	1
1.1.2 Lachlan Subregion	1
1.1.3 Study Area	1
1.1.4 Project Area	2
1.2 Physiography	3
2. MAP DESCRIPTION	4
3. SETTLEMENT AND POPULATION	6
3.1 Introduction	6
3.2 Population and Employment	7
4. RURAL LAND USE	9
4.1 Study Area Physiography	9
4.2 Cropping Industry	12
4.2.1 Introduction	12
4.2.2 Wheat	13
4.2.3 Barley	13
4.2.4 Oats	14
4.2.5 Other Winter Crops	14
4.2.6 Summer Crops	14
4.2.7 Horticulture	15
4.3 Livestock Industry	17
4.3.1 Introduction	17
4.3.2 Wool and Sheepmeat Industries	17
4.3.3 Beef Cattle and Dairying	19
4.3.4 Pig Industry	19
4.3.5 Horses	19
4.3.6 Beekeeping Industry	19
4.3.7 Other Livestock Industries	19
4.4 Forestry	23
4.5 Pastures Protection Boards	25
4.6 Value of Rural Industries	26

	<u>Page No.</u>
5. TRANSPORT AND TOURISM	29
5.1 Transport	29
5.1.1 Railways	29
5.1.2 Road Transport	29
5.1.3 Air Services	30
5.2 Tourism	32
6. WATER SOURCES AND USES	33
6.1 Bogan River System	33
6.1.1 Description, Course and Flow Durations	33
6.1.2 Uses	35
6.1.3 Water Quality	36
6.2 Groundwater	39
7. REFERENCES	40

TABLES

	<u>Page No.</u>
4.1 Establishments with Agricultural Activity (SAA and Shires)	10
4.2 Number of Agricultural Establishments Classified by Area (SAA)	11
4.3 Selected Cereals - Area and Production (SAA and Shires)	16
4.4 Oilseeds - Area and Production (SAA)	16
4.5 Sheep Numbers and Wool Clip (SAA and Shires)	18
4.6(a) Cattle Numbers (SAA and Shires)	20
4.6(b) Agricultural Establishments with Cattle (SAA)	20
4.7(a) Pig Numbers (SAA and Shires)	21
4.7(b) Agricultural Establishments with Pigs (SAA)	21
4.8 Horse and Goat Number (SAA)	22
4.9 Gross Value of Agricultural Production (SAA and Shires)	27
4.10 Regional Gross Value of Agricultural Commodities (SAA)	28
5.1 Traffic Counts - 1984	31
6.1 Flow Duration Data	34
6.2 Annual Water Usage - Irrigation	37
6.3(a) Water Quality - Bogan River	38
6.3(b) Water Quality - Bogan River	38

## 1. INTRODUCTION

### 1.1 Definition of Areal Terms

#### 1.1.1 Central Slopes Statistical Area

The basic unit of area used by the Australian Bureau of Statistics for the presentation of data in N.S.W. is the Statistical Division, which is further subdivided into Statistical Subdivisions and Districts. However, the Statistical Division is based on social and economic links within a part of the state and is not necessarily suitable for the presentation of agricultural data where the unifying link is likely to be climatic or topographic. Consequently the concept of the Statistical Agricultural Area was introduced for the presentation of agricultural data. These Statistical Agricultural Areas (SAA) reflect a level of homogeneity of agricultural activity.

The relevant SAA for the Goonumbla Project is the Central Slopes SAA which is identical with the Lachlan Statistical Subdivision of the Central West Statistical Division.

The Central Slopes SAA comprises the shires of Parkes, Lachlan, Forbes, Bland, Weddin and Cowra and the western portion of Cabonne.

#### 1.1.2 Lachlan Subregion

Generally referred to throughout the text as "the subregion", this informal term refers to the shires of Parkes, Forbes and Lachlan and takes in about half the Central Slopes SAA.

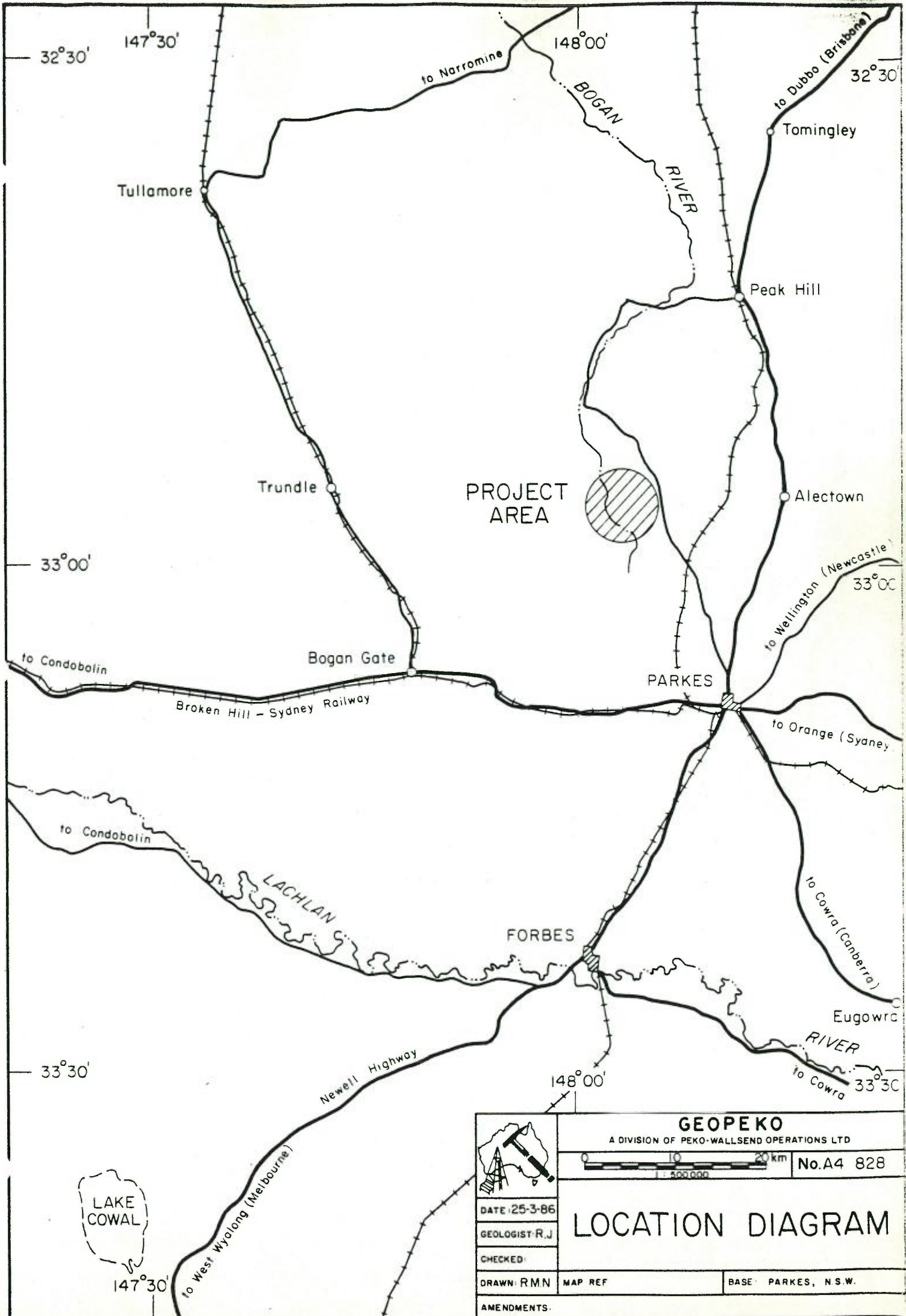
Where possible, generally for the more important or more relevant statistics, data are quoted in the tables for the three shires with a grand total for the Central Slopes SAA. Less important statistics (e.g. the numbers of goats or horses) are not available on a shire by shire basis and figures have been quoted for the entire Central Slopes SAA.


#### 1.1.3 Study Area

The study area is that area of Parkes Shire covered by the 1:25000 scale Land Use Map attached to this report. (Key mapsheet only included here).

#### 1.1.4 Project Area

The project area is a small section in the centre of the study area. It is the area likely to be substantially affected by possible mining operations at Goonumbla. This area of up to 5000ha is defined as being a circle of 4km radius around the centroid of the three prospects, Endeavours 22, 26 and 27.



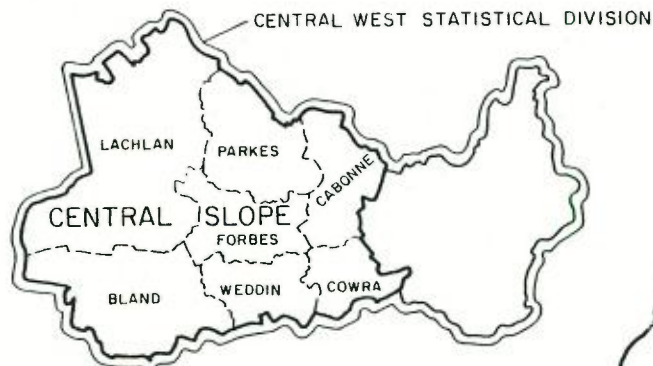
	<b>GEOPEKO</b>	
	A DIVISION OF PEKO-WALLSEND OPERATIONS LTD	
DATE: 25-3-86	No. A4 828	
GEOLOGIST: R.J.	<b>LOCATION DIAGRAM</b>	
CHECKED:		
DRAWN: RMN	MAP REF	BASE: PARKES, N.S.W.
AMENDMENTS:		

Queensland

South Australia

Tasman Sea

Victoria



- CENTRAL SLOPE STATISTICAL AGRICULTURAL AREA.
- CENTRAL WEST STATISTICAL DIVISION.
- - - - SHIRE BOUNDARY



**GEOPEKO**

A DIVISION OF PEKO-WALLSEND OPERATIONS LTD



No. A3 591

Date: 25-3-86

Geologist: R J

Checked:

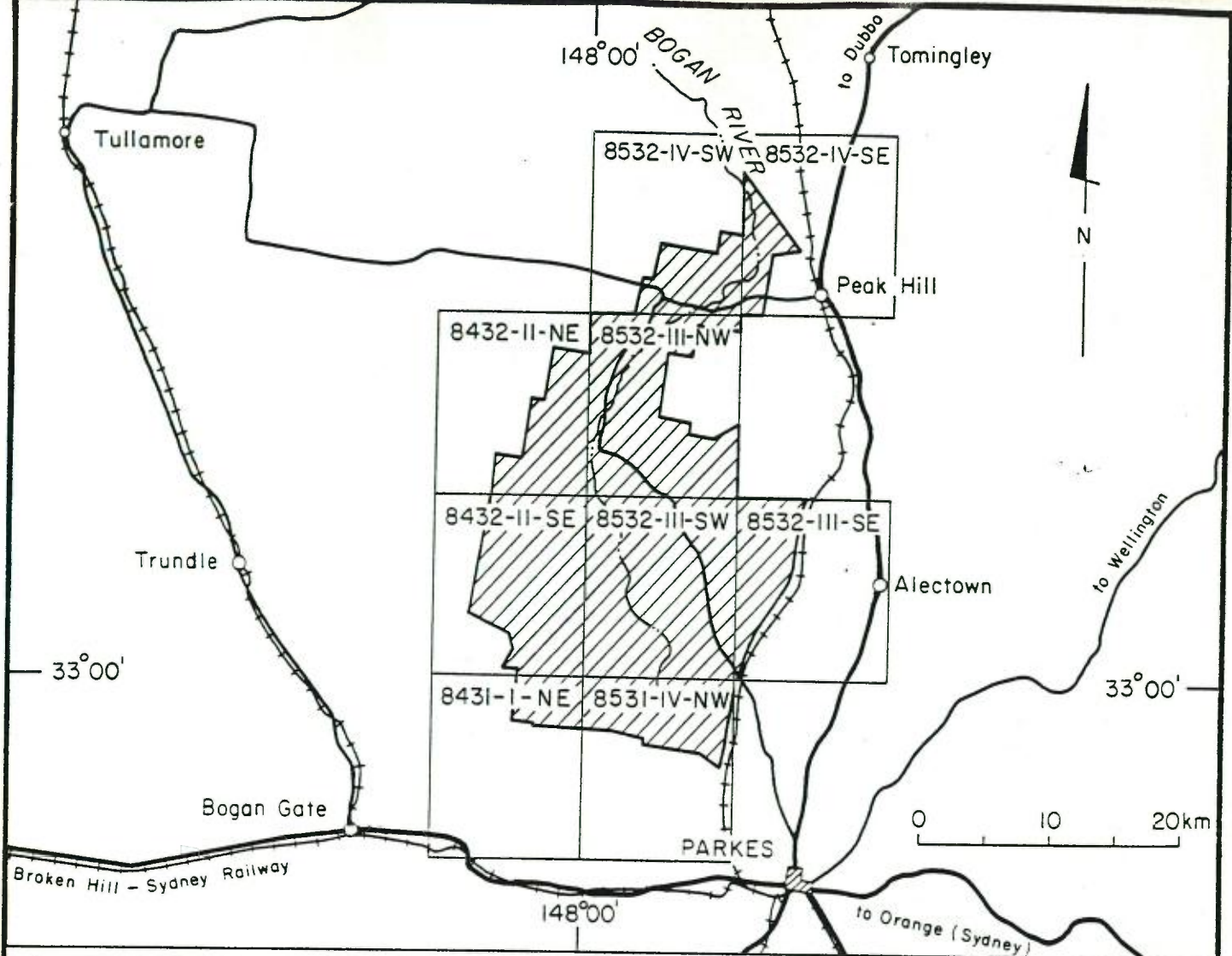
Drawn: RMN

Map Ref:










Base:



**PARKES NSW**

**CENTRAL SLOPE SAA  
SUBREGION & SHIRES**



**FEATURES MAPPED ON  
LAND USE MAPSHEETS**

- C Paddock regularly used for cropping.
- P Pasture paddock, rarely cropped.
-  Moderately Timbered
-  Lightly Timbered
-  Domestic Purposes
-  Dam
-  Watercourse (indistinct)
-  Major Watershed:  
Lachlan south & west, Bogan north & east.
-  Abandoned bore / well
-  Low yield bore / well
-  High yield bore (>3.8l/sec)

-  Location of mapsheet
-  Portion of mapsheet covered

Mapsheets are held by Geopeko,  
Parkes N.S.W.



**Natural Systems Research Pty. Ltd.**  
Environmental Consultants

**KEY DIAGRAM SHOWING COVERAGE  
OF LAND USE**

**1:25,000 MAPSHEETS**

**PARKES JOINT VENTURE**

**GOONUMBLA PROJECT**

Compiled by Geopeko / NSR

Date: JUNE 1986 A 4 885

**Figure**

## 1.2 Physiography

The Central Slopes SAA varies from hilly country on the western slopes of the Great Dividing Range in the east to virtually flat country in the west. The Lachlan River, which flows generally west north west through the area, bisects the Central Slopes SAA. In the northeast of the Central Slopes SAA drainage is northwards to the Macquarie River. The Bogan River rises near Parkes and flows parallel to, and west of, the Macquarie.

The average annual rainfall for the Central Slopes SAA varies from about 400mm in the west to 600mm in the east, in the project area it is about 500mm. The rainfall is uniform throughout the year. The rainfall variability (year to year) is moderate, the variability index ( $\frac{90-10}{50}$  percentiles) lying in the range 0.75-1.00.

The January average daily maximum temperature is around 33°C, the July average daily maximum temperature is about 15°C. The January and July average daily minimum temperatures are 15 and 2°C respectively. The Central Slopes SAA has a median number of frost days (<2°C) varying from 100 in the west to 200 in the east. Relative humidity is in the 50-80% range in winter and 30-60% range in summer. In both seasons the relative humidity increases to the east. The strongest wind vectors tend to be from the NE and SW octants in the study area. Annual evaporation varies from 2000mm in the east of the Central Slopes SAA to 2800mm in the west.

Major flooding in the area is rare, while this is in no small part due to the fact that in the slopes area catchments are not large, the construction of major dams on the Lachlan and Macquarie (Wyangala near Cowra and Burrendong near Wellington respectively) has further lessened the likelihood of major flooding. Minor floods do cause road and rail links to be cut for short periods. Droughts are not uncommon and have a major effect on the productivity of agricultural land.

## 2. MAP DESCRIPTION

The Land Use Mapping covers an area centred on the Limestone State Forest, which is the centre of possible mining activity, and extends to a radius of about 12-15km. In addition there is a north trending 'tail' along the Bogan River to Peak Hill. Mapping around the Bogan is generally of the order of 3km either side of the river.

Mapping is based solely on aerial photograph interpretation. The photographs were taken in May 1981 by Geo-Spectrum for Geopeko. The photographs are in colour and are at a nominal scale of 1:25000 (flt altitude 12,500', focal length 151.57mm, land surface approx. 280m ASL).

Details have been mapped onto 1:25,000 base maps prepared photogrammetrically by Geo-Spectrum in 1978-79 for Geopeko from N.S.W. Government aerial photography.

Land has been divided into four major categories:

- a) Land used for regular rotational cropping.
- b) Lightly timbered land which may be cropped occasionally but is predominantly used as pasture.
- c) Moderately timbered land which, because of the tree density, cannot be cropped at all.
- d) Cleared land which is not used for regular cropping. Such land may be too hilly, have rock outcrops, be highly erodible (e.g. along creek beds and banks), be gilgai country or be reserved for pasture due to a particular farm's emphasis on livestock rather than agricultural production.

In addition the following more restricted land uses have also been mapped:

- a) Domestic purposes land. This includes dwellings, machinery sheds, grain and fodder storage near the dwelling, stables, vegetable gardens, noncommercial orchards, piggeries, etc. This classification does not include structures such as hay sheds or grain storage sheds or silos isolated from the dwelling.
- b) Forests. In almost all cases forests are covered by grazing leases.

c) Stock reserves. These are generally along roads and are controlled by Pastures Protection Boards.

Other features which appear on the maps are dams, creeks and rivers, public roads, the Parkes-Narromine railway line, the Lachlan-Bogan Watershed, the Grain Handling Authority silos at Goonumbla and West Alectown, registered bores, as well as many fencelines.

It is possible that the area of regularly cropped land has been over-estimated at the expense of land used primarily for pasture but which is cropped occasionally. This is due to the fact that evidence of previous cropping, in particular the 'header lands' (i.e. the lines converging from paddock corners towards the centre of a paddock formed when headers and ploughs turn a corner), is distinguishable from the air for a number of years. In addition all land ploughed for the 1981 season has been included as regularly cropped land.

The 1:25,000 mapsheets are held by the Geopeko office in Parkes. A key to the mapsheets is included here.

### 3. SETTLEMENT AND POPULATION

#### 3.1 Introduction

Parkes was first established in the 1860s and early 1870s as a mining community following the discovery of gold at Currajong (about 3km north of Parkes) in 1862 and the Bushmans discovery in 1871. The mining industry waxed and waned throughout the remainder of the 19th century and gradually declined until at the end of the First World War mining was no longer an important undertaking in the Parkes Shire.

Prior to the discovery of gold there had been a small number of large pastoral holdings in what is now the Parkes Shire.

In 1873 the township of Bushmans was renamed Parkes in honour of (later Sir) Henry Parkes then a N.S.W. Member of the Legislative Assembly and later to become the N.S.W. Prime Minister. In 1883 Parkes was proclaimed as a Municipality. (The Municipality was amalgamated in 1981 with the surrounding Goobang Shire to form Parkes Shire.) In 1893 the railway line reached Parkes and in 1898 extended as far west as Condobolin.

Parkes Shire today covers some 5915 square kilometres. At June 30, 1984 there were 686 agricultural establishments with a total area of 502,980ha. The Shire's population at that date was estimated to be 14700, a decline of 0.29% pa since the last census in June 1981 (census population 14,850).

### 3.2 Population and Employment

The Shire of Parkes has an estimated population of 14,700 (at 30/6/84), approximately 9,500 of whom live in the town of Parkes. Only about 5% of the population is not Australian born and over half of these were born in other English speaking countries. Just over 65% of the population is aged over 18.

Apart from the town of Parkes other relatively stable centres in the Parkes Shire are Peak Hill, Trundle, Tullamore and Bogan Gate. Additionally there are a number of small villages mostly along the railway lines.

The labour force comprises 44.2% of the population, another 27.0% of the population is under 15 years of age. A breakdown of the labour force by occupation shows farmers to be the largest single group with 22% of the labour force. Other significant occupation groups are: tradesmen (19.9%), clerical workers (11.0%), professional and technical (10.1%), services, sport and recreation (9.6%), sales workers (8.5%). Miners make up only 0.6% of the labour force.

Government departments and authorities and local government are the biggest employers, there are few private enterprise employers with a large workforce in Parkes. The biggest employer in Parkes is the State Rail Authority with other major public employers being: Education Department, Central West County Council, Parkes Shire Council, Parkes District Hospital, Police Department, Grain Handling Authority (seasonal), Telecom and the Department of Main Roads. The army has a supply depot at Bogan Gate which may also be a significant employer. The two major private enterprise employers are Woolworths and Grace Bros with other significant employers being Cerebos (seasonal), Peko Wallsend and Van Reid Industries (sawmillers and house construction). Elsewhere in the shire du Pont at Bogan Gate is also a significant employer. At June 30, 1984 there were 26 manufacturing establishments operating in the shire, mainly in the steel fabrication and farm machinery supply areas, 15 of which employed four or more people. Averaged over the 1983-84 year 220 persons were employed in manufacturing establishments, less than 5% of the labour force.

Like other shires with only a small population the population has recently declined slightly and a breakdown of the population by age suggests that the 15-19, 20-24 and 25-29 age groups may be under-represented. Presumably this is due to school leavers and others not long out of school leaving the shire for higher education or to increase their chances of finding employment, or employment with better prospects, in Sydney or the provincial cities.

Services and facilities in Parkes are adequate for the present although water supply, sewerage and solid waste disposal may all require augmentation in the short to medium term.

4. RURAL LAND USE

4.1 Study Area Physiography

The subregion has a modified Mediterranean climate. Rainfall is relatively consistent throughout the year with slight peaks in summer and winter however there is a moisture deficit in the hotter months due to the high evaporation rate (typically 300-400mm/month). Median annual rainfall in the study area is about 500mm and average annual evaporation is around 2400mm. It can be seen that there is little available soil water during summer and consequently the cool season crops are far more important than summer crops.

Red brown earths are the dominant soil type. Fertility of these soils is generally poor and organic matter levels are low. The soils are deficient in phosphorus and nitrogen and, in many cases, sulphur.

The study area lies almost entirely within the top portion of the Bogan River catchment. For the most part this area is characterized by long very gentle slopes and plains with slightly more undulating topography in the south (around the Lachlan-Bogan watershed) and west (on the Devonian sediments).

Creeks are ill-defined, being more a zone of sheet wash than a continuous drainage with definite beds and banks. All watercourses within the study area are ephemeral. Natural standing water can be found in pools in the Bogan River below its confluence with Timalldrie Creek.

Table 4.1

## Establishments with Agricultural Activity

Number of Establishments, Area and Land Use, 1983-84

	<u>Establishments with Agricultural Activity</u>		<u>Land Use on Establishments with Agricultural Activity</u>	
	Number	Total Area(ha)	Area Cropped (ha)	Area Under Sown Grasses and clovers (ha)
Parkes Shire	686	502980	202165	35332
Forbes Shire	567	4 15177	168775	35318
Lachlan Shire	703	1415804	420003	58578
Central Slopes SAA	4363	4046430	1428344	458094

From Table 4, p7 Agricultural Land Use and Selected Inputs N.S.W. 1983-84  
Australian Bureau of Statistics.

Table 4.2

Number of Agricultural Establishments Classified by Area, at 31st March, 1984.  
Central Slopes SAA.

Area of Establishment (ha)	Number of Establishments(a)	Percentage
0(b)	29	0.7
>0 to <5	20	0.5
5 to <10	17	0.4
10 to <20	26	0.6
20 to <30	32	0.7
30 to <50	83	1.9
50 to <75	71	1.6
75 to <100	71	1.6
100 to <125	69	1.6
125 to <150	83	1.9
150 to <200	164	3.8
200 to <250	185	4.2
250 to <300	196	4.5
300 to <400	352	8.1
400 to <500	394	9.0
500 to <750	770	17.6
750 to <1000	507	11.6
1000 to <2000	891	20.4
2000 to <3000	212	4.9
3000 to <5000	136	3.1
5000 to <10000	42	1.0
10000 to <20000	13	0.3
TOTAL	4363	

a) An agricultural establishment is defined by the ABS for the 1983-84 figures as an establishment with an Estimated Value of Agricultural Operations of at least \$2500 for the 1983-84 season.

b) Beekeeping activities only.

From Table 6, p11, Agricultural Land Use and Selected Inputs, N.S.W., 1983-84.  
Australian Bureau of Statistics.

## 4.2 Cropping Industry

### 4.2.1 Introduction

Within the study area, and the subregion, wheat is the most important crop, with barley and oats also significant. Lesser amount of rapeseed, triticale and chickpeas are also grown. Summer crops are much less common due to the lack of effective summer moisture. Sunflowers and sorghum are the main summer crops in the study area. These crops, with soybeans and maize, are much more common in the subregion's irrigated area along the Lachlan River.

Farms in and near the project area are not large, averaging about 500ha. Throughout the study area the average farm size probably approaches 600ha. For the entire Central Slopes SAA the median farm size class is 500-750ha, see table 4.2.

Because of this relatively small farm size the project area's farms are not normally run on a strict crop rotation scheme, but rather the cropping cycle is extended by the repeated use of fertilizers. Fertilizer rates of about 10kg phosphorus/ha/crop year are common. Nitrogenous fertilizers are sometimes used on second and subsequent crops in place of superphosphate.

Where crop rotation is used an arable paddock is cropped for three to five years. The final crop is usually undersown with a leguminous pasture species. The length of the pasture part of the cycle is variable (commonly about 3 years) being controlled primarily by the profitability of pastoral production compared with crop production, and also by the success of the legume species which depends largely on the weather conditions over the rehabilitation period.

Gypsum, used to improve soil structure, is not infrequently added to the soil at a rate of about 1 tonne/ha.

#### 4.2.2 Wheat

Wheat is the predominant crop within both the study area and subregion. The Central Slopes SAA is the state's major wheat producing region. The 2.2 million tonne harvest in the Central Slopes SAA in the 1983-84 season represents 24.6% of the N.S.W. production.

Wheat is sown in late autumn-early winter and harvested in late spring-early summer. Average yields are in the vicinity of 1.5-1.7t/ha. Table 4.3 shows cereal production figures for the 1983-84 season. It should be noted that 1983-84 was an exceptional season in that it was the first good season after the drought. Rainfall was above average for the season and a larger than average crop was sown (second largest sowing on record). The N.S.W. average yield at 2.24t/ha, was the highest recorded. The state's 8.96 million tonne production was far better than the previous highest harvest of 6.64 million tonnes (1978-79) and almost six times higher than the 1982-83 season harvest. The average yield for the Central Slopes SAA in 1983-84 was 2.40t/ha.

#### 4.2.3 Barley

Barley is important in the study area as it matures more quickly than wheat and is less affected by drought seasons and low rainfall. Most barley is sown later than wheat although some is sown early to provide winter grazing for stock before being harvested. The barley grown in the subregion is mostly suitable for malting although significant proportions are sold as feed grain or used on farm as livestock feed.

In the subregion about ten times more land is sown to wheat than barley. As for wheat the 1983-84 season was particularly good. The N.S.W. barley production in 1983-84 (941,000 tonnes) was over 10 times the previous year's production. Barley production for 1983-84 is shown in table 4.3.

#### 4.2.4 Oats

Oats requires more water than barley or wheat and is tolerant of wetter conditions. Oats can be sown for grain, for grazing followed by harvesting, for grazing alone or for hay. An oats crop is commonly the first grown in a rotational sequence as it makes more efficient use of the nitrogen enriched soil than do the other major cereals. Oats paddocks are commonly used for winter grazing when grasses are dormant. As with barley the area sown to oats in the subregion is generally about one tenth of that sown to wheat.

In the 1983-84 season (see table 4.3) the state's oats production was a record 1.12 million tonnes. The area sown to oats was higher than usual due to the necessity to replenish stock feed supplies depleted by several years of harsh drought. In the vicinity of the project area in 1984-85 it was noticeable that there was a relatively small area sown to oats after the previous year's bumper crop however the area sown to barley appeared to be somewhat greater than usual.

#### 4.2.5 Other Winter Crops

Small but increasing areas of rapeseed, chickpeas and triticale are being sown in the subregion. Rapeseed and chickpeas production are likely to increase as varieties with better disease resistance are introduced. Rapeseed is ideally used as the first crop in a rotation sequence as it breaks the disease cycle. Chickpeas are a grain legume and if sown as the third or fourth crop can extend the cropping sequence by a season or two. Chickpeas are used in pig and poultry food and as drought feed for sheep. Triticale, a wheat-rye hybrid, is a high protein cereal which is becoming more popular. Its cultivation and uses are similar to those of stock feed barley. Triticale production for 1983-84 is shown in table 4.3 and rapeseed production in table 4.4.

#### 4.2.6 Summer Crops

Summer crops are a rarity in the study area, and in the subregion tend to be restricted to the irrigation areas along the Lachlan River. Grain sorghum and sunflowers are the two most common summer crops in the study area. Success with these crops depends, in the first instance, on the occurrence of good early summer rains. Sorghum production is shown in table 4.3; sunflower, and other oilseeds more common along the Lachlan, production in table 4.4.

#### 4.2.7 Horticulture

Vegetable and fruit production occurs around Forbes where the crops are irrigated from the Lachlan River. Crops grown include tomatoes, melons, grapes, cauliflower, cabbage, broccoli and some stone, citrus and pome fruits. There is no commercial horticulture in the study area.

Table 4.3

Selected Cereals - Area and Production.

	Wheat for grain		Oats for grain		Barley for grain		Sorghum for grain		Triticale for grain	
	Area Sown(ha)	Production (tonnes)	Area Sown(ha)	Production (tonnes)	Area Sown(ha)	Production (tonnes)	Area Sown(ha)	Production (tonnes)	Area Sown(ha)	Production (tonnes)
Parkes Shire	136502	357252	28862	43509	18133	38575	49	115	666	1400
Forbes Shire	106683	259964	19408	28741	18084	36030	142	558	1389	3444
Lachlan Shire	288721	624407	76578	106871	33744	61122	636	1265	2188	3201
Central Slopes SAA	916750	2200592	240380	340476	114770	212932	1075	2377	8403	17530

From Table 7, pp12-13, Crops and Pastures N.S.W. 1983-84  
Australian Bureau of Statistics.

Table 4.4

Oilseed - Area and Production

Central Slopes SAA

	Linseed	Rapeseed	Safflower	Soybeans	Sunflower	Total
Area Sown (ha)	371	1471	300	215	1048	3404
Production (tonnes)	209	1627	60	314	1022	3232
Yield/ha	0.56	1.11	0.20	1.47	0.98	

Form Tables 28 and 29, pp31-32, Crops and Pastures N.S.W. 1983-84  
Australian Bureau of Statistics.

### 4.3 Livestock Industry

#### 4.3.1 Introduction

In the subregion the principal animal production industries are wool growing in the west and fat lamb and wool production in the east. Beef cattle are also raised on some farms however this is rarely the primary activity. Pig farming is also a significant enterprise however this too is usually a sideline to cereal production.

As with cereal production, 1983-84 was not a normal year for the livestock industry. The effects of the breaking of the drought were not as marked on the livestock industry as they were on the cropping industry. Many farms started to restock in 1983-84. Flocks and herds had become depleted during the drought as farmers sold stock for slaughter because the carrying capacity of the land was decreased and also because income was required to supplement the minimal returns from crops.

#### 4.3.2 Wool and Sheepmeat Industries

In the hotter and drier parts of the subregion sheep are bred mainly for wool. In the cooler and wetter areas the raising of lambs for slaughter is as important as the wool industry.

The Merino is the most important of the wool breeds. In the Central Slopes SAA at 31.3.84 over 70% of sheep were Merino or Merino comeback. For prime lamb production the Merino is generally crossed with the Border Leicester to produce the prime lamb dam (first cross ewe). The prime lamb sire is usually Corriedale or Poll Dorset stock with British Downs breeds gaining importance. In the study area the wool industry is significantly more important than the lamb meat industry and lambs for slaughter are commonly Merino x Border Leicester or surplus Merino stock. The study area is intermediate between the almost exclusively wool production area and the prime lamb area.

Table 4.5 shows the sheep numbers and wool production in the subregion for 1983-84.

Table 4.5 Sheep Numbers and Wool Clip

	At 31.3.84			y.e. 31.3.84		
	Sheep 1yr & over	Lambs & hoggets Less than 1yr	Total Sheep	Sheep & Lambs Shorn	Total Wool Clip (greasy)	Ave Clip (greasy) (kg)
Parkes Shire	616965	164001	780966	797103	3372296	4.2
Forbes Shire	551465	152963	704428	753348	3166201	4.2
Lachlan Shire	853723	266331	1120054	1184886	5439121	4.6
Central Slopes SAA	4623763	1295488	5919251	6203071	27207534	4.4

From tables 13 and 26, pp28 and 47. Livestock and Livestock Products  
New South Wales 1983-84. Australian Bureau of Statistics.

#### 4.3.3 Beef Cattle and Dairying

Some farms in the study area run small beef cattle herds as a sideline to cereal and sheep production. Main breeds are Poll Hereford, Hereford, Shorthorn, Poll Shorthorn and Angus.

There are no dairies in the study area although some dairy farming is carried out along the Lachlan on irrigated country. Some study area farms do keep a few dairy cattle for on farm use with the added result that a small number of vealers are produced. Cattle numbers in the subregion are shown in table 4.6(a).

#### 4.3.4 Pig Industry

Several farms in the study area have small piggeries. As far as is known all are run as a sideline to Cereal and sheep production. Table 4.7(a) shows pig numbers for the subregion.

#### 4.3.5 Horses

Parkes is the centre of a thriving harness racing 'industry' and a small number of farms also operate as standardbred horse studs. On other farms, including several in the study area, small numbers of pacers are bred or trained. There is no stud within the study area although there is a major stud just east of the study area between Goonumbla and West Alectown.

#### 4.3.6 Beekeeping Industry

This is a very minor industry in the region however hives are often seen during the flowering season of Patersons Curse and Eucalypt (particularly Box) species. For the most part these hives are to be seen on stock reserves and tend to be operated by town dwellers and itinerant beekeepers.

#### 4.3.7 Other Livestock Industries

There is small scale goat farming in the subregion however no production is known from the study area. Forbes Abattoir has a licence to butcher goats.

The poultry industry in the Central Slopes SAA is relatively small amounting to some 161000 birds (all fowls). It is not known what proportions are egg strain and meat strain birds.

Table 4.6 (a)  
Cattle at March 31, 1984

	Dairy Cattle(a)	Beef Cattle(a)	House Cows	Total
Parkes Shire	195	12521	417	13133
Forbes Shire	640	27108	254	28002
Lachlan Shire	256	43477	326	44059
Central Slopes SAA	2654	186763	2537	191954

(a) includes bulls.

From Table 5, pp12-13, Livestock and Livestock Products N.S.W. 1983-84  
Australian Bureau of Statistics.

Table 4.6 (b)  
Agricultural Establishments with Cattle  
Central Slopes SAA

31.3.1982	2643
31.3.1983	2425
31.3.1984	2313

From Table 2, p3, Livestock and Livestock Products N.S.W. 1983-84  
Australian Bureau of Statistics

Table 4.7(a)  
Pigs at March 31, 1984

	Boars	Sows and Gilts	Other Pigs	Total
Parkes Shire	233	2868	13188	16289
Forbes Shire	183	2646	10264	13093
Lachlan Shire	218	3302	12873	16393
Central Slopes SAA	1251	16405	77481	95137

From Table 31, p57, Livestock and Livestock Products N.S.W. 1983-84  
Australian Bureau of Statistics.

Table 4.7(b)  
Agricultural Establishments with Pigs  
Central Slopes SAA

31.3.1982	963
31.3.1983	889
31.3.1984	831

From Table 29, p52, Livestock and Livestock Products N.S.W. 1983-84  
Australian Bureau of Statistics.

Table 4.8

## Horses and Goats in Central Slopes SAA

	Horses (a)	Goats (a)
31.3.1982	7842	11017
31.3.1983	6522	9836
31.3.1984	6417	12773

(a) On establishments with agricultural activity.

From Table 38, p64, Livestock and Livestock Products N.S.W. 1983-84  
Australian Bureau of Statistics.

#### 4.4 Forestry

The Forbes Forestry District covers an area from Tomingley in the north, south along the Parkes Shire boundary west of Trundle, south to the Lachlan River, to Lake Cowal and Weethallie, southwest of West Wyalong to Cootamundra then east of Young to Wyangala. From there the boundary runs north through Cudal and Molong then northwest to Tomingley. This is a much larger area than the subregion discussed earlier.

In this area are 67 / <sup>gazetted</sup> forests covering about 83,000ha although about 27,000ha of this are the relatively unproductive hardwood forests of the Hervey Range.

There are some 30,000ha of white cypress forests in the Forbes District. Four sawmills within the district (including one in Parkes and one in Eugowra) are supplied from these forests. White cypress is, economically, the most important of the timbers in the district, being white and rot resistant. Both black cypress and hardwood trees are also felled, the main uses for the hardwoods being fence posts and railway sleepers. There are no radiata pine forests in the district as the rainfall is too low and summers too hot.

There are no available figures as yet for sustained yield of the forests although an assessment has recently been carried out.

The Forestry Commission estimates that the white cypress forests yield 1m<sup>3</sup> of useable timber per hectare per annum. This yields a royalty of about \$20/m<sup>3</sup>.

Many of the forests are leased out for grazing, the type of grazing being dependent on the management practices required for a particular forest. There is no grazing on forests undergoing the first stages of regeneration. In the next (small sapling) stage grazing by cattle is encouraged. Once the tops of saplings are out of the reach of sheep (or goats) and regeneration has been good, grazing by sheep or goats is required to stop further regeneration. In addition to regeneration control grazing has the added benefits of bushfire fuel reduction and revenue. Thinning of regenerated forests currently costs about \$250/ha.

There appears to be an 80 year cycle for white cypress forests from regeneration to regeneration. Many of the cypress forests in the Forbes district are still operating on an 1890's regeneration, the next substantial regeneration did not occur until 1952 due to the deleterious effects of overgrazing and high rabbit populations. Because of the 60yr span between regenerations it has been, and still is, necessary to eke out the timber of the 1890's regeneration until trees of subsequent regenerations reach maturity.

Both the Limestone State Forest and the Wombin State Forest had their last regeneration in the 1890s. Logging has ceased in the Limestone State Forest leaving about 9 cypress/ha for seed trees, ready for the start of regeneration. There are probably two more cuts to be made from Wombin Forest before it, too, is allowed to regenerate.

Figures are not available to permit a full assessment of the value of the forestry industry to the subregion however overall it is probably not a major contributor to the economy. In isolated cases the industry is very important, e.g. Eugowra which would possibly not exist were it not for the town's sawmill as the town is at no great distance from Forbes or Parkes.

#### 4.5 Pastures Protection Boards

Pastures Protection Boards are quasi-autonomous organizations under the control of the Minister for Agriculture set up to administer the Pastures Protection Act 1934. These boards are responsible for such matters as noxious animal control, stock brands and earmarks, travelling stock, camping reserves and public watering places, veterinary inspection of stock at saleyards, contagious animal diseases and noxious insects. Shire Councils are responsible for policing the provisions of the Local Government Act pertaining to noxious plants.

The eastern portion of the study area, including the project area, falls under the control of the Molong Pastures Protection Board, the western portion under Forbes Pastures Protection Board. Molong Pastures Protection Board controls a Travelling Stock Reserve along the Bogan Road. In the study area this reserve runs from the Goonumbla railway crossing to the Peak Hill-Tullamore Road. (The reserve continues further to the north under the Molong P.P. Board and further to the southeast under Forbes P.P. Board.) Along this, and every, TSR is a series of camping reserves, usually with stock yards and a stock watering facility (either a dam or access to a waterhole in a creek, etc.) These camping reserves are situated at intervals considered to be a day's walk for stock (about 10km). The P.P. Boards levy rates on travelling stock for the use of the TSRs. In the Molong P.P. Board area agistment is not permitted on TSRs although this is allowed by Forbes P.P. Board.

Any public road can be declared a temporary Travelling Stock Reserve at any time.

#### 4.6 Value of Rural Industries

Tables 4.9 and 4.10 show the Gross Value of Agricultural Production (GVAP) in the 1983-84 season for the subregion's shires and, broken down by commodity, for the Central Slopes SAA respectively.

It has not been possible to determine a GVAP for the properties in the project area and the Parkes Shire average value (\$170.9/ha) has been used. The project area land is among the best in the shire having a higher rainfall than the areas in the west and being flatter and thus more suitable for cultivation than the eastern parts of the shire.

Within the project area farming activities are typical of the Shire with cereal production, especially wheat, and the raising of sheep primarily for wool but also for lamb meat the major activities. One landholder concentrates on fat lamb production with wool and cereal production being less important. There are no cattle herds in the study area although one farm bordering the study area has a Hereford herd. On one farm in the project there are a few dairy cattle but there is no commercial production. At present there is no pig production in the area because of economic conditions however there are two piggery structures.

Assuming the project area to be enclosed by a circle with radius 4km, there are 50.3 square kilometers in the project area (5,030ha). Without allowing for roads or the Limestone State Forest the GVAP for this area in 1983-84 is thus about \$860,000.

This figure is inflated by the inclusion of the forest and roads and by the fact that 1983-84 was an exceptionally good season however this may be balanced by the fact that the average GVAP for Parkes Shire may underestimate the productivity of this land.

While this figure is, of necessity, approximate and as nett figures are not available it appears to be a reasonable estimate of the productivity of this small area.

Table 4.9  
 Gross Value of Agricultural Products  
 1983-84 Season

	No. of establishments with agricultural activity	Total Area of establishments (ha)	Gross value agricultural commodities (\$'000)	Ave value agricultural prod per ha. (\$)
Parkes Shire	686	502980	85962	170.9
Forbes Shire	567	415177	76758	184.9
Lachlan Shire	703	1415804	146954	103.8
Central Slope SAA	4363	4046430	591999	146.3

From Table 2(h), pp52-55, 1986 Regional Statistics N.S.W.

Australian Bureau of Statistics

and Table 10, p19, Value of Agricultural Commodities Produced N.S.W. 1983-84

Australian Bureau of Statistics.

Table 4.10

Regional Gross Value of Agricultural Commodities Produced, N.S.W., 1983-84 (\$'000)  
Central Slope SAA

## Agricultural Commodities

## Crops

Wheat for grain	361962
Barley for grain	30347
Sorghum for grain	301
Cereal hay and other cereals for grain	33384
Total	425994

Oilseeds	959
Pasture seed	875
Lucerne and pasture hay	22011
Fruit and nuts	2374
Vegetables	5157
All other crops	1716

Total crops	459086
-------------	--------

## Livestock Products

Wool	81102
Milk	1183
Eggs	2054
Honey and beeswax	665
Total	85004

## Livestock Slaughtering and Disposals

Sheep and lambs	16936
Cattle and calves	21590
Pigs	8774
Poultry	608
Total	47908

Total Value of Agricultural Commodities Produced	591999
--	--------

From Table 10, p19, Value of Agricultural Commodities Produced N.S.W., 1983-84  
Australian Bureau of Statistics.

## 5. TRANSPORT AND TOURISM

### 5.1 Transport

Although Parkes owes its founding to the discovery of gold it is probably to the transport industry that Parkes owes its continued existence.

Parkes lies on the trans continental railway line and on the Newell Highway, the shortest major route between Brisbane and Melbourne or Adelaide.

#### 5.1.1 Railways

The State Rail Authority is the biggest employer in Parkes, in 1985 there were some 350 employees in Parkes (Parkes tourist brochure). When the standard gauge rail link between Sydney and Perth was completed in 1969 Parkes became the marshalling and dispersal terminal for eastern Australia. Most of the subregion's wheat crop is railed from the Grain Handling Authority's Muginoble sub terminal (8km east of Parkes) to the coast.

Rail passenger services through Parkes *not any more!* include the Indian Pacific (Sydney-Perth), Silver City Comet (Orange-Broken Hill) and local services to Orange to connect with the XPT to Sydney and Silver City Comet to Broken Hill. Branch lines (freight only) run from Parkes to Forbes and Stockinbingal and Parkes to Peak Hill and Narromine. The State Rail Authority also runs coach services to Forbes, Harden and Tottenham.

#### 5.1.2 Road Transport

The Newell Highway is the main Melbourne-Brisbane and Adelaide-Brisbane heavy transport link. Road distances to the capital cities are: Sydney 365km, Canberra 306km, Melbourne 721km, Adelaide 1067km and Brisbane 995km. In addition Trunk Road 61 runs from Condobolin through Parkes to Orange where it connects with the Mitchell Highway to Sydney. Main Road 233 connects Parkes with Wellington, part of the shortest route to Newcastle and Main Road 238 leads to Cowra and then Canberra.

Table 5.1 shows traffic counts for 1984 on all major roads. Only the Newell Highway counter near the Bogon Road (the road to the project area) is a permanent counter.

### 5.1.3 Air Services

Eastern Airlines operate a twice daily commuter service between Parkes, Forbes and Sydney. In the year ended 31/12/81 there were over 13000 passenger movements and 1028 aircraft movements at Parkes Airport, however operations at the airport have subsequently been reorganized with the cessation of scheduled airline service and the introduction of the commuter service. Flying time to Sydney is about 1 hour.

Table 5.1  
Traffic Counts - 1984

<u>Route</u>	<u>Location</u>	<u>Ave. Ann. Daily Traffic</u>
State Highway 17 (Newell Highway)	Bogan Rd, 3km N Parkes	2890 vehicles/day
	Town centre	9470
	Trewilga ( 40km N)	2510
	Forbes Shire Bdry ( 20km S)	2970
Trunk Road 61 (Orange Rd) (Condobolin Rd)	Billabong Ck ( 3km E)	1450+
	Level Crossing ( 6km W)	890
	Gunningbland ( 20km W)	660
	Bogan Gate ( 35km W)	730
Main Road 233 (Wellington Rd)	Tanks Lane (2km E)	470
	8km NE	290
Main Road 238 (Eugowra Rd)	Billabong Ck ( 3km SE)	1500
	Bartleys Ck ( 12km SE)	350

+ estimated due to unreliable count.

Main Roads Department figures.

## 5.2 Tourism

Parkes Shire's major tourist attraction is the CSIRO's radiotelescope 23km north of Parkes. Over 1 million visitors have inspected the telescope at a rate of about 60,000 per year. Other attractions in the shire include the Parkes Motor Museum, Henry Parkes Historical Museum (10,000 visitors p.a.), the open cut gold mine at Peak Hill and the Grain Handling Authority subterminal at Mugincoble. Major attractions outside the shire but at no great distance from Parkes are the Western Plains Zoo at Dubbo and Lachlan Vintage Village at Forbes.

In the June quarter of 1985 there were 9 motels and hotel/motels in Parkes Shire with a total of 186 guest rooms and 579 beds. Room and bed occupancy rates were 52% and 32.8% respectively. Gross takings from accommodation for the year were \$1,235,000 (ABS figures).

Quarterly figures for 1983-84 show a small peak in guest nights in hotels/motels in winter and spring, possibly due to southern states residents visiting and returning from Queensland and northern New South Wales.

The Australian Bureau of Statistics estimates that in 1983-84 the tourist industry in Parkes Shire was worth \$15.9 million. Almost 400,000 visitor nights were estimated for Parkes Shire over the same period (Parkes Tourist Centre, unpublished data).

Parkes Shire Council established a Tourist Centre in the town in 1984. In its first full year of operation this centre attracted over 20,000 visitors.

There seems to be little in the Parkes Shire to attract tourists for an extended stay and the aim of the Tourist Centre is to turn the interstate travellers' one night stopover into a two or three day stay.

## 6. WATER SOURCES AND USES

### 6.1 Bogan River System

#### 6.1.1 Description, Course and Flow Durations

The project area lies in the furthest headwaters of the Bogan River. In this area there is no obvious stream bed, the Bogan existing as a very gentle linear depression containing a number of disconnected, shallow (30-50cm) almost invariably dry, holes.

On the rare occasions when the Bogan does flow in this area the flow is a shallow, sluggish sheet of water. These flows are usually interrupted by the series of farm dams along the course of the Bogan.

The Bogan first develops discernible bed and banks just upstream of the confluence with Timalldrie Creek. Despite having only half the catchment of the Bogan to this point (80sq km for Timalldrie, 165sq km for Bogan) Timalldrie Creek flows much more often and appears to be largely responsible for the permanent standing water in the Bogan River about two hundred meters above the confluence.

The Bogan remains ephemeral at least as far as Nyngan. The Warren Weir, on the Macquarie River, directs some water, through a regulator, to Gunningbar Creek. Further structures divert water, amongst other courses, to the Albert Priest Canal which carries water for the town supplies of Nyngan and Cobar. When surplus flows permit water may be released from the Nyngan weirs to the Bogan River. Gunningbar Creek supplies the Bogan River with an annual replenishment for stock and domestic purposes from the confluence to the Barwon River.

Flow duration statistics from the Water Resources Commission stations on Burrill Creek at Mickibri and on the Bogan River near Peak Hill show that in the period 1973-1984 and 1967-1984 respectively these streams flowed less than 30% of the time. (Burrill Creek flows into Ten Mile Creek which enters the Bogan just above Peak Hill.) Flows in excess of 100 ML/day occurred only about 2% of the time at Mickibri and 9% of the time at Peak Hill.

Table 6.1

## Flow Duration Data, Cumulative Frequency %

Discharge (ML/day)	Mickibri	Peak Hill
0	100	100
>0	29.7	27.0
>10	12.0	19.1
>15	9.7	17.1
>20	7.7	16.2
>25	6.5	15.5
>30	5.8	14.8
>40	4.5	13.8
>50	3.6	12.9
>60	3.1	12.5
>80	2.5	10.9
>100	2.1	8.9
>150	1.4	7.1
>200	1.0	5.9
>250	0.8	5.2
>300	0.6	4.7
>400	0.5	4.1
>500	0.4	3.4
>600	0.4	2.8
>800	0.2	2.0
>1000	0.2	1.8
>1500	0.1	1.2
>2000	0.1	0.9
>2500		0.8
>3000		0.7
>4000		0.4
>5000		0.3
>6000		0.3
>8000		0.2
>10000		0.1

From Water Resources Commission unpublished data.

Notes: Mickibri - Station 421084 1973-1984  
 Peak Hill - 421076 1967-1984

### 6.1.2 Uses

The Water Resources Commission has licensed about 60 works on the Bogan River upstream of the Gunningbar Creek confluence. Two of these works are upstream of Peak Hill.

The majority of the works are small centrifugal pumps used to obtain stock and domestic water or for irrigation. Other works include small overshot dams, a diversion channel for irrigation and a cutting to prevent inundation.

The two operations upstream of Peak Hill are an overshot dam for stock and domestic water and Parkes Shire Council's weir near the confluence of the Bogan and Ten Mile Creek and a channel connecting the two streams. Peak Hill Weir is no longer used to supply the town with water. Peak Hill's water supply has been from the Lachlan bores since 1967.

Irrigation using water from the Bogan may be authorized however this authorization is for a maximum area of land per property which can be irrigated rather than for a maximum volume of water which may be used. The maximum authorized area for the Bogan is 20.5ha. Ten irrigation licences have been issued for the Bogan upstream of the upper reaches of the Nyngan Weir system. The total authorized area is 184ha. Table 6.2 shows the water used for irrigation.

Any landholder owning property adjoining the river may pump water from the river for stock or domestic use. No authority is required.

In the study area the Bogan River is used as the watering facility by the Molong Pastures Protection Board at Genanaguy Reserve.

As there are no large towns on the Bogan and better water recreation sites are to be found on other rivers relatively nearby (e.g. the Lachlan is near the Bogan headwaters, the Macquarie is near the middle reaches and the Darling-Barwon system is near the lower reaches) the Bogan is not much used for recreation purposes except by the relatively sparse farming population living nearby.

Recreational uses of the Bogan River above Nyngan include swimming and fishing. Fish species present include the natives yellowbelly, silver perch and possibly Murray cod. The most prolific species in the Bogan River, as with most inland rivers, is the introduced

European carp, a noxious species which causes great damage to the habitat of the native fish. Redfin (or English perch), a voracious cannibal species, are also present in some of the quieter waters. Redfin also cause damage to the native species, by eating fingerlings, but are not treated by fishermen with the same disdain as European carp because the redfin is edible.

### 6.1.3 Water Quality

Table 6.3(a) from Muir and Johnson (1978) lists a series of water analyses from the Bogan River. There is a marked break in the analyses at Nyngan corresponding to the Albert Priest Canal influx. It is not possible to determine whether this change in water characteristics ( $K^+$ ,  $Na^+$ ,  $Cl^-$ ,  $SiO_2$  decrease; pH,  $Ca^{2+}$ ,  $Mg^{2+}$ ,  $SO_4^{2-}$ ,  $HCO_3^-$  increase) is associated simply with the change of provenance of the water or whether it is related to the fact that the three upstream samples were from still or very slow flowing water while "from Nyngan onwards the river was observed to contain an appreciable volume of fast flowing water" (p399). It should be noted that, from near Dubbo the Macquarie River flows across artesian water bearing sediments while the Bogan flows just to the west of this basin.

Table 6.3(b) shows water analyses from within and immediately to the north of the project area. The first series of results is from a stock dam in the Bogan, the other from the highest natural standing water in the Bogan.

Table 6.2

## Annual Water Usage - Irrigation, megalitres

y.e.	30/6/81	30/6/82	30/6/83	30/6/84	30/6/85
Above Albert Priest Canal	0.4	329.7	1.4	28.8	0.8
Canal to Nyngan Weir	3315.4	3091.1	475.1	964.0	702.0
Below Nyngan Weir	14.7	989.2	10.8	1504.7	3388.2
Total	3330.5	4410.0	487.3	2497.5	4091.0

From Water Resources Commission returns.

Table 6.3(a)

## Water Quality - Bogan River

Date Sampled	Location	pH	Conductivity (25°C) $\mu\text{Scm}^{-1}$	K <sup>+</sup> mg/l	Na <sup>+</sup> mg/l	Ca <sup>2+</sup> mg/l	Mg <sup>2+</sup> mg/l	Cl <sup>-</sup> mg/l	SO <sub>4</sub> <sup>2-</sup> mg/l	HCO <sub>3</sub> <sup>-</sup> mg/l	SiO <sub>2</sub> mg/l
15/5/75	Peak Hill	7.4	435	19.2	31.5	10.4	9.6	36.1	9.0	176	9.7
15/5/75	Dandaloo	7.1	370	11.2	40.0	14.8	6.9	57.4	8.3	93	11.0
15/5/75	Buddabadah	7.5	460	13.3	47.0	16.6	8.5	75.1	9.0	98	11.5
15/5/75	Nyngan	7.9	380	8.1	33.1	20.9	10.3	32.5	17.0	122	2.0
15/5/75	Girilambone turnoff	8.1	370	2.8	26.9	23.1	13.0	29.0	21.1	122	4.7
15/5/75	Monkey Bridge	8.2	365	2.6	26.9	22.6	12.8	32.5	23.0	112	4.0
15/5/75	Gongolgon	7.8	400	2.9	28.8	24.0	13.8	36.1	22.0	122	4.5
15/5/75	Road Bridge E of Bourke	7.9	360	2.9	25.2	22.6	12.5	32.5	22.0	117	4.5

From Table 2, p401, Muir and Johnson (1978)

Table 6.3(b)

1982-1985	Dam, project area median value	6.9	137	6.8	15.6	5.2	3.6	11	5	74	na
(no. of samples)		(38)	(25)	(6)	(6)	(6)	(6)	(20)	(6)	(20)	
Nov.-Dec. 1985	Timalldrie Creek confluence antecedent rain mean value	6.3	165	7.4	20.4	4.3	3.9	18.3	9.3	55	na
(no. of samples)		(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	(8)	

Geopeko data

## 6.2 Groundwater

Little is known of the groundwater potential of the Bogan River area as no study has yet been carried out.

The Water Resources Commission stated that, "aquifer recharge through the fractured rocks area northwest of Parkes ... [project area and environs] is by direct infiltration of rainfall and side-slope runoff. Because of the low permeability of these rocks, recharge is considered small." (written comm, 20/2/86). There are a number of registered bores in the study area and these are indicated on the Land Use map. With the exception of one bore in Burrill Creek at Mickibri all are either abandoned bores/wells or have a low yield (<3.8L/s).

Analyses carried out for the Goonumbla Joint Venture project show that, in the project area, water quality varies from tolerable to poor. In general samples taken from areas at a distance from mineralization are suitable for sheep watering, although generally not for other stock, however yields are poor. In mineralized areas, yields may be better but water quality is worse. At Endeavour 26 analyses have consistently returned total salt values of about 25000 mg/L.

No work is known on groundwater studies downstream of the project area.

7. REFERENCES

Data sources used in compiling tables have been attributed at the foot of the table. Other data sources are as follows:

- 1.1.1 Central Slopes Statistical Area  
New South Wales Year Book No. 69 1985,  
p4, Australian Bureau of Statistics.
- 1.2 Physiography  
Climatic data from  
Cribb, J. (ed) National Farmers Federation Australian Agricultural  
Year Book 1985, Strand Publishing Pty. Ltd.  
pp131-142.
- 3.1 Settlement and Population - Introduction  
Tindall, R. (ed) 1983 Parkes-One Hundred  
Years of Local Government (privately published).
- 3.2 Population and Employment  
1986 Regional Statistics New South Wales  
Australian Bureau of Statistics pp52-55.  
Census 1981 Characteristics of Persons and Dwellings  
in Local Government Areas N.S.W. Part 2 p88.
4. Rural Land Use  
Throughout this section much of the general  
information came from conversations with  
Goonumbla district landholders.
- 4.2 Cropping Industry  
Crops and Pastures New South Wales 1983-84  
Australian Bureau of Statistics.  
Cribb, J. (ed) National Farmers Federation Australian  
Agricultural Year Book 1985 Strand Publishing Pty. Ltd.  
pp68-88, 249-283
- 4.3 Livestock Industry  
Livestock and Livestock Products New South Wales 1983-84  
Australian Bureau of Statistics.

- 4.4 Forestry  
Discussion with Mr. W. Horton, Forbes District Forester, N.S.W. Forestry Commission.
- 4.5 Pastures Protection Boards  
Discussions with Messrs. K. Oliver and R. Evers, Secretary and Ranger of the Molong Pastures Protection Board.
5. Transport and Tourism  
Parkes Shire Tourist Guide, July 1985 (tourist brochure)  
Parkes - Centre of N.S.W. (development brochure)  
(both available from Parkes Tourist Information Centre).  
Phone conversation with officers of N.S.W. Department of Main Roads, Parkes.  
New South Wales Year Book No. 69 1985, p360  
Australian Bureau of Statistics.  
Unpublished data, Parkes Tourist Information Centre.
- 5.2 Tourism  
Conversation with Mr. M. Greenwood, Parkes Shire Tourist Officer.  
1986 Regional Statistics New South Wales  
Australian Bureau of Statistics pp54-55.
6. Water Sources and Uses  
Discussions with, and written communication from, officers of the N.S.W. Water Resources Commission, Sydney and Dubbo.  
Draft Water Management Plan for the Macquarie Marshes 1985, Water Resources Commission and National Parks and Wildlife Service.  
Muir, G.L. and Johnson, W.D., 1978, Chemistry of the Bogan River, N.S.W., with special reference to the sources of dissolved material. Aust J. Mar. Freshwater Res., 29 pp399-407.

**APPENDIX B**

**ENVIRONMENTAL WATER STUDY**

Warman International Ltd.  
Research & Development Division  
May 1986.

# WARMAN INTERNATIONAL LTD.

TELEGRAMS & CABLES  
"WARMANCO" SYDNEY  
PHONE: 436 6789  
TELEX: AA20711

POSTAL ADDRESS  
P.O. BOX 51  
ARTARMON  
N.S.W. 2064  
AUSTRALIA

LABORATORIES.  
6-8 MCLACHLAN AVE  
ARTARMON  
SYDNEY  
NEW SOUTH WALES

AIB:sh  
86/1326

RESEARCH & DEVELOPMENT DIVISION REPORT

Report 85/174890-2

Goonumbla Project: Preliminary Feasibility Study

Environmental Water Study

for

Peko-Wallsend Ltd

A.I. Bellingham  
D.B. Hewes

May 6, 1986

1. INTRODUCTION

The Warman Laboratory undertook a programme of laboratory testing in response to a scope-of-work statement issued by Natural Systems Research Pty Ltd.

The objective of the testwork was to assess the extent to which heavy metals present in the Goonumbla tailing would be expected to report in the dissolved phase in simulated run-off streams.

This report presents

- \* The scope-of-work statement from A. Sharp-Paul.
- \* Warman laboratory instructions presenting details of the procedures applied in response to the scope-of-work statement.
- \* Analytical Certificates of the tailing solids from Analytical Services (WA) Pty Ltd.
- \* Analytical Certificates of the simulated water streams from SGS Australia Pty Ltd.

No attempt has been made to interpret the results of the work, this being outside our brief and the responsibility of Natural Systems Research Pty Ltd.

2. SCOPE-OF-WORK

Copy of memo from Natural Systems Research to Warman Laboratory,  
March 3, 1986.

---

MEMO

---

FROM : A. Sharp-Paul  
DATE : 3 March 1986  
JOB NO. : 312  
PAGES : 4  
(Including this page)

Natural Systems Research P/L  
25 Burwood Road  
Hawthorn Vic. 3122  
Australia

Tel: (03) 818-0264  
Tlx: AA 31585 ASSVIC  
Fax: (03) 819-2101

---

TO : Warman Sydney  
ATTN : A.E. Bellingham

COPIED TO : Knight, PWL Syd  
: Sinclair, Geopeko  
:

RE : Goonumbla Environmental  
Testwork

---

The objective of the testwork is to determine whether heavy metals present in the tailings report to the dissolved phase (passing 0.45 $\mu$ m filter), after simulated admixture to catchment runoff.

From various samples collected during a period of intense rainfall, we have selected Sample 4 to be the diluent representative of catchment runoff. The basis for the selection is that of the eight collected in total, Sample 4 displayed the lowest pH and was judged to be the worst case as far as ability to mobilise heavy metals. The samples were similar in this respect and the choice of Sample 4 is not critical.

The total tailings slurry should be shaken, then allowed to settle for the period at which material still in suspension is judged to be generally <10 $\mu$ m. The decanted supernatant and contained fines (S/n + <10 $\mu$ m) are taken to represent the component of the tailings that would make up the dam overflow in the event of intense rainfall exceeding the dam freeboard.

**Sample Type A:** 2 samples should be sent to Analytical Services (WA) Pty. Ltd for ICP-MS scan comprising:

- total tailing slurry;
- 0.45 $\mu$ m filter cake from supernatant and contained <10 $\mu$ m fines.

**Sample Type B:** the matrix of samples in this category is given in Table 1.

TABLE 1: Aeration-Dilution Testwork Matrix

Location	Waste	Diluted by	With	Aeration Time
Tailings	S/n +<10 $\mu$ m	-	-	-
At discharge	"	x2	Rainwater	24
Bogan	"	x270	Sample 4	36
Timalderie	"	x820	Sample 4	48
Rainwater	-	-	-	-
Sample 4	-	-	-	-

The rainwater and Sample 4 water will be reconstituted from standard values and the Sample 4 analysis sheet respectively.

The following procedure should be applied to all samples in the matrix in Table 1:

- (a) Carry out dilution and aeration steps according to the matrix;
- (b) Split samples into 2; filter one through 0.45 $\mu$ m, acidify filtrate (5 ml conc. nitric acid per 1L) and hold in acid-washed bottle;
- (c) Analyse samples as follows:
  - Unfiltered samples      conductivity, pH, alkalinity, NFR (TSS), SO<sub>4</sub>, TDS, major ions, total metals (Cu, Pb, Zn, V, As, Co, Ni, Mo, Hg, U).
  - Filtered samples      dissolved metals (Cu, Pb, Zn, V, As, Co, Ni, Mo, Hg, U).

Quality control samples should be included as appropriate. Will the metal analyses be done by SGS? If so, the levels of detection should be as for Sample 4.

Kind regards

A handwritten signature in black ink, appearing to read 'Alastair Sharp-Paul'.

Alastair Sharp-Paul



SOURCE OF WATER	FLOOD - GWQ		FLOOD - GWQ			
SAMPLE No.	2		4			
DATE OF COLLECTION						
Conductivity (25°C μmhos cm <sup>-1</sup> )	160		158			
Total Filterable Residue (mg/L @ 180°C)						
Total Hardness (EDTA) as mg/L CaCO <sub>3</sub>						
Calculated Hardness as mg/L CaCO <sub>3</sub>	23		26			
pH	6.1		6.0			
	mg/L	mEq/L	mg/L	mEq/L	mg/L	mEq/L
Sodium Na <sup>+</sup>	18	0.783	17	0.740		
Potassium K <sup>+</sup>	6.8	0.174	7.6	0.194		
Calcium Ca <sup>++</sup>	3.6	0.180	4.0	0.200		
Magnesium Mg <sup>++</sup>	3.5	0.288	3.8	0.313		
		1.425		1.447		
Chloride Cl <sup>-</sup>	14	0.395	14	0.395		
Carbonate CO <sub>3</sub> <sup>=</sup>	Nil	-	Nil	-		
Bicarbonate HCO <sub>3</sub> <sup>-</sup>	55	0.902	51	0.836		
Sulphate SO <sub>4</sub> <sup>=</sup>	9	0.187	7	0.146		
Nitrate NO <sub>3</sub> <sup>-</sup>						
Fluoride F <sup>-</sup>	0.09	0.005	0.08	0.004		
Total Alkalinity (As CaCO <sub>3</sub> )	45	-	42	-		
		1.489		1.381		
Total Iron Fe						
Silica SiO <sub>2</sub>						
NON Filterable Residue	52		44			
Total Phosphorus	0.77		0.83			



This Laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of registration. This document shall not be reproduced except in full.

*S. Hanna*

3. PROCEDURES

Copy of Warman Laboratory instructions, March 12, 1986.



GOONUMBLA PROJECT

ENVIRONMENTAL WATER STUDY: LABORATORY INSTRUCTIONS

Project No 85/174890

Refer attached memo from Natural Systems Research Pty Ltd

1. Containers

- (a) one polythene container in clear and otherwise good condition to hold 12 litres of "simulated flood water".

Wash it out with detergent and then rinse several times with tap water.

- (b) 12 x 1 litre polythene water sample bottles and caps.

Wash well with detergent and then rinse several times with tap water.

Take 4 of these bottles and caps and go through the following acid wash procedure.

- (a) rinse with 1:1 nitric acid
- (b) rinse with tap water
- (c) rinse with 1:1 hydrochloric acid
- (d) rinse with tap water
- (e) rinse with distilled water.

Identify the acid washed bottles for use later in the procedure.

2. Simulated Rain Water

Take 2 of the tap water rinsed bottles and fill with distilled water (1 litre). Label one bottle

SAMPLE 7

SIMULATED RAIN WATER

Mark and retain the other bottle for preparing the "discharge samples" described below in Section 7.



3. Simulated Flood Water

Take 12 litres of distilled water and add chemicals to yield an analysis similar to "sample 4" on the last page of the attachment.

Put about 500 ml of this water into one of the tap-water-rinsed bottles, and label

SAMPLE 8

SIMULATED FLOOD WATER

Hold the remainder for work described below in Sections 5 and 6.

4. Preparation of Tailing

Float 750 g of composite G7 in recycled Parkes water left over from the locked cycle test. Use an 8 minute grind and follow our standard procedure; call it float 57.

Prepare the concentrates to assay samples and take a tailing sample from the cell.

At the end of the float, transfer the tailing to a 3 litre beaker and allow to settle for 1 to 2 hours. Measure the distance from the surface of the liquor to the settled interface, and do a Stokes Law calculation to determine the time for a 10  $\mu\text{m}$  particle to settle that distance (say X minutes). Now stir the slurry well and let it settle for X minutes, then decant the liquor and non-settled  $-10 \mu\text{m}$  fines into a clean beaker; call it "tailing water suspension" and retain it for use as described below.

Take the settled solids, dry it and then take out a 100 g assay sample. Label it

SAMPLE 1

TAILING SOLIDS

(Note: See Section 9 following before drying the tailing solids).

### 5. Timalderie Samples

Take 8.2 litres of simulated flood water into a clean polythene or pvc mixing tank. Set up a mechanical agitator to produce a mild turbulence in the mixing tank.

Take the tailing water suspension prepared above (2 to 3 litres) and agitate it strongly to produce an even dispersion. Withdraw 10 ml of tailing water suspension in a pipette and transfer it to the 8.2 litres of simulated flood water. Agitate with mild turbulence for 48 hours.

After 48 hours, while the system is still agitating, withdraw a sample of 500 to 1000 ml and put it into a tap-water-rinsed bottle. Label

SAMPLE 6A

TIMALDERIE

Stop the agitator and allow the solids to settle for several hours.

Take 500 ml of settled liquor and filter it through 0.45  $\mu$ m Millipore paper.

Put the filtrate in an acid-washed bottle and add 5 ml/litre of concentrated nitric acid. Label

SAMPLE 6B

TIMALDERIE

### 6. Bogan Samples

Take 2.7 litres of simulated flood water into a clean polythene or pvc mixing tank. Set it up with an agitator as for the Timalderie sample, add 10 ml of tailing suspension and agitate with mild turbulence for 36 hours.

After 36 hours, while still agitating, withdraw a 500 to 1000 ml sample and put it in a tap-water-rinsed bottle. Label

SAMPLE 5A

BOGAN

Stop the agitator, and allow the solids to settle for several hours, then filter 500 ml of settled liquor through a 0.45  $\mu$ m Millipore filter.

Put the filtrate in an acid-washed bottle and add 5 ml/litre of conc nitric acid. Label

SAMPLE 5B

BOGAN

7. Discharge Samples

Agitate the tailing water suspension and take 800 ml into a clean 2-litre beaker. Add 800 ml of the simulated rainwater and agitate with mild turbulence for 24 hours. While still agitating, withdraw about 500 ml into a tap-water-rinsed bottle. Label it

SAMPLE 4A  
DISCHARGE

Stop the agitator and allow the solids to settle for several hours, then filter 500 ml of liquor through a 0.45  $\mu$ m Millipore filter. Put the filtrate in an acid-washed bottle and add 5 ml/litre of conc nitric acid. Label it

SAMPLE 4B  
DISCHARGE

8. Tailing Water

Agitate the tailing water suspension and take 500 ml into a tap-water-rinsed bottle. Label it

SAMPLE 3A  
TAILING WATER

Allow the remainder of the tailing water sample to settle. Note the volume. Then filter it all through a 0.45  $\mu$ m Millipore filter.

Take about 500 ml of the filtrate into an acid-washed bottle, add 5 ml/litre of conc nitric acid and label it

SAMPLE 3B  
TAILING WATER

9. Tailing Fines

Take the 0.45  $\mu$ m filter cake prepared in the previous section, dry, weigh and label

SAMPLE 2  
TAILING FINES

Note: Phone C. Eldridge at Analytical Services (WA) (09) 457-1496 and ask him what is the minimum weight of sample required for an ICP-MS scan.



If the weight of tailing fines is less than the minimum weight, prepare more tailing fines as follows:

Repulp the settled tailing solids (Section 4) with tap water, to the original volume mark, and repeat the settling/decant procedure. Then allow the decanted solids to settle and filter them through an 0.45 µm Millipore paper. Dry the solids, weigh and combine with the previously prepared batch.

10. Sample Analyses

Samples 1 and 2 go to Analytical Services (WA) Pty Ltd for ICP-MS scan.

Address: 19 Augusta Street  
Willetton WA 6155

All the other samples go to SGS:

\* Samples 3A, 4A, 5A, 6A, 7, 8 for

conductivity

pH

alkalinity

suspended solids

dissolved solids

major ions: Na<sup>+</sup>, K<sup>+</sup>, Ca<sup>++</sup>, Mg<sup>++</sup>, Cl<sup>'</sup>, CO<sub>3</sub><sup>''</sup>, HCO<sub>3</sub><sup>'</sup>, SO<sub>4</sub><sup>''</sup>

total metals: Cu, Pb, Zn, V, As, Co, Ni, Mo, Hg, U

\* Samples 3B, 4B, 5B, 6B for

dissolved metals: Cu, Pb, Zn, V, As, Co, Ni, Mo, Hg, U.

---

A.I. Bellingham

March 12, 1986

4. RESULTS

1. ICP-MS scan on total tailing (SAMPLE 1) and tailing fines (SAMPLE 2).  
Work by Analytical Services (WA) Pty Ltd.
2. Water analyses by SGS Australia Pty Ltd

<u>Sample No</u>	<u>Location</u>	<u>Filtered</u>
3A	Tailing	NO
3B	Tailing	YES
4A	Discharge	NO
4B	Discharge	YES
5A	Bogan	NO
5B	Bogan	YES
6A	Timalderie	NO
6B	Timalderie	YES
7	Simulated rain water	NO
8	Simulated flood water	NO

The unfiltered samples, 3A, 4A, 5A, 6A, 7 and 8 were analysed for conductivity, pH, alkalinity, total filterable residue, non-filterable residue (TSS), sulphate, chloride, carbonate, bicarbonate, sodium, potassium, calcium, magnesium and total heavy metals as listed on page 4 of the SGS report.

The filtered samples were analysed for dissolved metals as listed on page 4 of the SGS report.

REFERENCE NUMBER 28460

16 APR., 1988

ORDER NUMBER 54002650

Warman International Ltd.  
XXXXXXXXXXXXXXXXXXXXXXXXXXXX

P O Box 51

ARTARMON NSW 2064

Analysis of Tailings Samples  
XXXXXXXXXXXXXXXXXXXXXXXXXXXX

ANALYSED BY :  
ANALYTICAL SERVICES (WA) PTY LTD  
19 AUGUSTA ST  
WILLETTON WA 6155  
TELEPHONE 457 1498 457 2569  
TELEX AA 94767

AUTHORISED BY : C.L. ELDRIDGE



\*\*\*\*\*

Sample Det Limit

Li = < 100 ppb	Be = < 20 ppb	Hf = < 20 ppb	Mg = < 20 ppm	Al = < 500 ppm	P = < 50 ppb
S = < 50 ppb	K = < 20 ppb	Ca = < 20 ppm	Ti = < 1 ppm	V = < 2 ppm	Cr = < 2 ppb
Mn = < 2 ppb	Fe = < 500 ppm	Ni = < 2 ppm	Co = < 500 ppb	Cu = < 2 ppm	Zn = < 5 ppb
Ga = < 100 ppb	Ge = < 5 ppb	As = < 1 ppm	Se = < 5 ppm	Rb = < 50 ppb	Sr = < 200 ppb
Y = < 50 ppb	Zr = < 200 ppb	Nb = < 500 ppb	Mo = < 200 ppb	Pd = < 50 ppb	Ag = < 200 ppb
Cd = < 500 ppb	In = < 20 ppb	Sn = < 500 ppb	Sb = < 100 ppb	Te = < 1 ppm	Cs = < 5 ppb
Ba = < 500 ppb	La = < 100 ppb	Ce = < 50 ppb	Pr = < 20 ppb	Nd = < 100 ppb	Sm = < 50 ppb
Eu = < 20 ppb	Gd = < 50 ppb	Tb = < 20 ppb	Dy = < 50 ppb	Ho = < 20 ppb	Er = < 50 ppb
Tm = < 10 ppb	Yb = < 50 ppb	Lu = < 20 ppb	Hf = < 500 ppb	Ta = < 100 ppb	W = < 500 ppb
Re = < 50 ppb	Pt = < 200 ppb	Au = < 100 ppb	Tl = < 50 ppb	Pb = < 20 ppb	Bi = < 200 ppb
Th = < 50 ppb	U = < 50 ppb				

Sample 1

TOTAL

TAILING SOLIDS

Li = 4.8 ppm	Be = 1.2 ppb	Hf = 2.4 ppb	Mg = 5400 ppm	Al = 5.4 %	P = 900 ppb
S = 1400 ppb	K = 41.5 %	Ca = 5300 ppm	Ti = 1900 ppm	V = 78 ppm	Cr = 58 ppb
Mn = 370 ppm	Fe = 1.6 %	Hf = 2.4 ppb	Co = 3.8 ppm	Cu = 760 ppm	Zn = 70 ppm
Ga = 5.6 ppm	Ge = 5 ppb	As = 2.5 ppm	Se = < 5 ppm	Rb = 72 ppb	Sr = 290 ppm
Y = 6.7 ppm	Zr = 75 ppb	Nb = 6.7 ppm	Mo = 4.6 ppm	Pd = 100 ppb	Ag = 400 ppb
Cd = < 500 ppb	In = < 20 ppb	Sn = 1.5 ppm	Sb = 900 ppb	Te = < 1 ppm	Cs = < 5 ppm
Ba = 620 ppm	La = 81.2 ppb	Ce = 16 ppb	Pr = 1.5 ppm	Nd = 5.9 ppm	Sm = < 50 ppb
Eu = 140 ppb	Gd = 1.5 ppm	Tb = 200 ppb	Dy = 1.3 ppm	Ho = 280 ppb	Er = 750 ppb
Tm = 180 ppb	Yb = 1.1 ppm	Lu = 260 ppb	Hf = 1.5 ppm	Ta = 1.0 ppm	W = 2.2 ppm
Re = < 50 ppb	Pt = 200 ppb	Au = < 100 ppb	Tl = 350 ppb	Pb = < 20 ppb	Bi = < 200 ppb
Th = 1.7 ppm	U = 100.5 ppb				

Sample 2

TAILING FINES

Li = 6.9 ppm	Be = 1.7 ppb	Hf = 2.2 ppb	Mg = 8800 ppm	Al = 8.1 %	P = 850 ppb
S = 2000 ppb	K = 5.7 %	Ca = 7300 ppm	Ti = 2000 ppm	V = 110 ppm	Cr = 38 ppb
Mn = 370 ppb	Fe = 2.1 %	Ni = 18 ppb	Co = 6.1 ppm	Cu = 1000 ppm	Zn = 210 ppm
Ga = 7.9 ppm	Ge = 5 ppb	As = 5.5 ppm	Se = < 5 ppm	Rb = 90 ppb	Sr = 190 ppb
Y = 5.7 ppm	Zr = 35 ppb	Nb = 6.7 ppm	Mo = 4.7 ppm	Pd = 100 ppb	Ag = 1.4 ppb
Cd = < 500 ppb	In = 60 ppb	Sn = 5.4 ppb	Cd = 20 ppb	Te = < 1 ppm	Cs = < 5 ppm
Ba = 600 ppb	La = 5.5 ppb	Ce = 11 ppb	Tl = 1.3 ppm	Nd = 5.4 ppm	Sm = < 50 ppb
Eu = 40 ppb	Gd = 1.3 ppm	Tb = 180 ppb	Dy = 1.2 ppm	Ho = 260 ppb	Er = 600 ppb
Tm = 140 ppb	Yb = 1.1 ppb	Lu = 260 ppb	Hf = 2.3 ppm	Ta = 1.3 ppm	W = 6.6 ppm
Re = < 50 ppb	Pt = < 200 ppb	Au = 200 ppb	Tl = 400 ppb	Pb = 200 ppm	Bi = 2.0 ppm
Th = 1.5 ppm	U = 1.1 ppb				

\*\*\*\*\*

## NOTES ON ANALYSIS OF THESE SAMPLES

These elements have been determined on the sample after digestion with Nitric, Hydrofluoric and Perchloric acids to fumes. The digest has then been taken up in Nitric and Hydrochloric acids. This digest approaches total extraction for many elements, however some minerals, particularly Chromite and Cassiterite and high levels of some of the refractory minerals, may not be recovered in total. Although reported, Zirconium, Hafnium and Titanium results via this digestion will probably be low.

The elements Na and K have been determined by Atomic Absorption.

The elements . . . Mg, Cr, Mn, Ni, As, Fe, Ti, Ca, Al, Zn, Cu, P and S have been determined by Optical Emission Plasma Spectrometry.

All other elements have been determined by Inductively Coupled Plasma - Mass Spectrometry.

Since short integration times have been used in assessing element concentrations, these results should be considered SEMI-QUANTITATIVE.

The element detection limits for this analytical run have been reported, and consideration should be given to them in relation to low level positive results on samples.



# SGS Australia Pty. Ltd.

(Incorporated in N.S.W.)

74 McEvoy St.,  
Alexandria NSW 2015  
Telephone (02) 699 7625,  
Telex 22395  
NATA Reg. No. 1062

WARMAN INTERNATIONAL LTD  
P.O. Box 51  
ARTARMON / NSW 2064

Attention: Mr D.B. Hewes

REPORT NO . LA. 4606 . . CLIENT REF. NO . . SY. 002652 . . . . .  
DATE SAMPLES IN . 26/3/86 . . . DATE REPORT OUT 24/4/86 . . . . .

## WATER ANALYSIS REPORT

The tests contained in this report have been carried out in accordance with the APHA standard methods 15th Edition, or other NATA approved methods listed below:

402	Acidity
403	Alkalinity
403	Bicarbonate
507/421F	Biochemical Oxygen Demand
406B	Carbon Dioxide (Free)
403	Carbonate
508A	Chemical Oxygen Demand
407A	Chloride
205	Conductivity
412B/C	Cyanide
421F	Dissolved Oxygen
315B	Ferrous/Ferric Iron
209B	Filterable Residue
413B	Fluoride
314A/B	Hardness Total
417E	Nitrogen - Ammonia
418B	Nitrogen - Nitrate
419	Nitrogen - Nitrite
420A	Nitrogen - Total
209D	Non-Filterable Residue
503A	Oil and Grease
424F	Orthophosphate
423	pH
424C/F	Phosphorus Total
425A	Silica
426A	Sulphate
214A	Turbidity
AAS	Fe, Mn, Na, K, Ca, Mg.



SOURCE OF WATER	TAILING WATER		DISCHARGE		BOGAN	
SAMPLE No.	3A		4A		5A	
DATE OF COLLECTION						
Conductivity (25°C μmhos cm <sup>-1</sup> )	4900		2000		360	
Total Filterable Residue (mg/L @ 180°C)	3170		1640		225	
Total Hardness (EDTA) as mg/L CaCO <sub>3</sub>						
Calculated Hardness as mg/L CaCO <sub>3</sub>						
pH	7.4		7.3		6.7	
	mg/L	mEq/L	mg/L	mEq/L	mg/L	mEq/L
Sodium Na <sup>+</sup>	230	10.005	115	5.003	23	1.001
Potassium K <sup>+</sup>	55	1.406	28	0.716	8.4	0.215
Caesium Ca <sup>++</sup>	520	25.948	265	13.224	10	0.499
Magnesium Mg <sup>++</sup>	48	3.949	25	2.057	16	1.316
		41.308		21.000		3.031
Chloride Cl <sup>-</sup>	170	4.796	92	2.595	74	2.088
Carbonate CO <sub>3</sub> <sup>=</sup>	Nil		Nil		Nil	
Bicarbonate HCO <sub>3</sub> <sup>-</sup>	68	1.115	36	0.590	16	0.262
Sulphate SO <sub>4</sub> <sup>=</sup>	1850	38.536	940	19.580	28	0.583
Nitrate NO <sub>3</sub> <sup>-</sup>						
Fluoride F <sup>-</sup>						
Total Alkalinity	56	-	29	-	13	-
		44.447		22.765		2.933
Total Iron Fe						
Silica SiO <sub>2</sub>						
Non Filterable Residue	485		170		<1	



This Laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of registration. This document shall not be reproduced except in full.

*D. Hanna*



SOURCE OF WATER	TIMALDERIE		SIMULATED RAIN WATER		SIMULATED FLOOD WATER	
SAMPLE No.	6A		7		8	
DATE OF COLLECTION						
Conductivity (25°Cµ mhos cm <sup>-1</sup> )	320		6		315	
Total Filterable Residue (mg/L @ 180°C)	230		18		212	
Total Hardness (EDTA) as mg/L CaCO <sub>3</sub>						
Calculated Hardness as mg/L CaCO <sub>3</sub>						
pH	6.3		4.7		6.3	
	mg/L	mEq/L	mg/L	mEq/L	mg/L	mEq/L
Sodium Na <sup>+</sup>	22	0.957	< 0.1	-	19	0.827
Potassium K <sup>+</sup>	8.2	0.210	< 0.1	-	7.2	0.184
Calcium Ca <sup>++</sup>	7.0	0.349	< 0.1	-	4.0	0.200
Magnesium Mg <sup>++</sup>	16	1.316	< 0.1	-	15	1.234
		2.832		-		2.445
Chloride Cl <sup>-</sup>	74	2.088	< 2	-	74	2.088
Carbonate CO <sub>3</sub> <sup>=</sup>	Nil		Nil		Nil	
Bicarbonate HCO <sub>3</sub> <sup>-</sup>	11	0.180	< 2	-	14	2.230
Sulphate SO <sub>4</sub> <sup>=</sup>	15	0.313	< 0.2	-	16	0.333
Nitrate NO <sub>3</sub> <sup>-</sup>						
Fluoride F <sup>-</sup>						
Total Alkalinity	9		< 2	-	12	
		2.581		-		2.651
Total Iron Fe						
Silica SiO <sub>2</sub> Non						
Filterable Residue	< 1		< 1		< 1	



This Laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of registration. This document shall not be reproduced except in full.

*Signature*



NEW SOUTH WALES  
74 McEvoy St., Alexandria, Sydney, N.S.W. 2015  
Telephone 699 7625 Telex: SGSSYD AA22395

WESTERN AUSTRALIA  
80 Railway Parade, Queens Park  
Telephone 458 1421 Telex: SGSPTH AA92624

A 4606

Our ref .....

Your ref .....

Date received .....

Date completed.....

Issued at .....

**ANALYTICAL REPORT**

Sample Ref.	Cu	Pb	Zn	V	As	Co	Ni	Mo	Hg	U
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1 <u>DISSOLVED METALS</u>										
2 3B TAILING WATER	6.5	29	42	3	1.0	100	3450	< 1	< 0.1	0.4
3 4B DISCHARGE	7.0	12	20	4	3.0	20	200	< 1	< 0.1	0.6
4 5B BOGAN	9.0	3.0	26	< 1	< 0.5	2.0	10	< 1	< 0.1	0.4
5 6B TIMALDERIE	8.0	4.5	30	< 1	< 0.5	2.0	6.5	< 1	0.2	< 0.4
6										
7 <u>TOTAL METALS</u>										
8 3A TAILING WATER	440	45	89	10	2.5	45	48	3	< 0.1	< 0.4
9 4 DISCHARGE	150	33	62	12	5.5	15	76	4	< 0.1	< 0.4
10 5A BOGAN	13	2.5	12	< 1	< 0.5	2.5	11	< 1	< 0.1	< 0.4
11 6A TIMALDERIE	10	5.0	21	< 1	< 0.5	3.0	4.0	< 1	0.1	< 0.4
12 7 SIMULATED RAIN WATER	< 0.5	< 0.5	< 0.5	< 1	< 0.5	1.0	< 0.5	< 1	< 0.1	< 0.4
13 8 SIMULATED FLOOD WATER	8.0	4.0	14	5	< 0.5	2.5	1.0	< 1	0.4	0.4
14										
15	HGA	HGA	HGA	HGA	HYDRIDE	HGA	HGA	HGA	Cold Vapour	
16	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	AAS	
17										
18										
19										
20										

*D. Hanna*

## APPENDIX C

### CLIMATIC DATA FOR PARKES

TABLE AC-1            Mean monthly and annual rainfall figures  
for Parkes and Peak Hill.

TABLE AC-2            Average temperature readings for Parkes  
(elevation 340 m) based on 26 years of record.

Source: Croft (1981). Parkes Copper Prospect: A report on Environmental  
Constraints (2 volumes). James B. Croft & Associates  
Pty. Limited. Consultant Report to Peko-Wallsend Ltd.

APPENDIX C  
CLIMATIC DATA FOR PARKES

TABLE AC-1

Mean Monthly and Annual Rainfall Figures (mm)  
for Parkes and Peak Hill

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Parkes	50.8	36.5	44.0	39.8	40.0	53.8	44.5	44.8	39.0	40.0	39.5	48.5	520.3
Peak Hill	53.0	36.0	44.3	43.5	38.8	48.8	43.0	41.3	33.8	38.5	37.3	45.5	503.5

Source: Forestry Commission of N.S.W. Tech. Paper No. 8 (1967), *in* Croft (1981).

APPENDIX C  
CLIMATIC DATA FOR PARKES

TABLE AC-2

Average Temperature Readings for Parkes (elevation 340 m)  
Based on 26 Years of Record

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Average Maximum (°C)	32.6	32.0	28.6	23.3	18.9	14.8	13.9	15.8	19.9	24.1	28.5	30.9	23.6
Average Minimum (°C)	17.9	17.9	15.3	11.1	7.7	5.4	4.3	5.4	7.6	10.6	14.0	16.5	11.2
Average Daily (°C)	25.2	25.0	21.9	17.2	13.3	10.1	9.2	10.6	13.7	17.3	21.3	23.7	17.4
Highest on record: 45.6°C						Lowest on record: -6.1°C							

Source: Water Resources Commission of N.S.W., *in* Croft (1981).

## APPENDIX D

### BIRD HABITAT MANAGEMENT

1. Bird species list
2. Main plant species found around the project site
3. Bird species for which the re-vegetation could be targeted
4. Corridors/re-vegetation

Neville Schrader, Parkes  
June 1990

Attachment 1. BIRD SPECIES LIST

Birds recorded between 1975 - 1990 within 1 kilometre radius of the Project Area. The extent of this list denotes the importance of Adavale Lane woodland corridor and the Bogan River. Unfortunately timber removal and heavy grazing in the last few years appears to have severely modified Limestone State Forest.

No attempt has been made to allocate status to individual species. Many are summer or winter visitors, with others seasonal vagrants. Those species marked with an '\*' are regularly observed within the area.

001	Emu	<i>Dromaius novaehollandiae</i>
061	*Australasian Grebe	<i>Tachybaptus novaehollandiae</i>
096	Great Cormorant	<i>Phalacrocorax carbo</i>
097	*Little Black cormorant	<i>Phalacrocorax sulcirostris</i>
100	Little Pied Cormorant	<i>Phalacrocorax melanoleucos</i>
189	*Pacific Heron	<i>Ardea pacifica</i>
188	*White-faced Heron	<i>Ardea novaehollandiae</i>
187	Great Egret	<i>Egretta alba</i>
186	*Plumed Egret	<i>Egretta intermedia</i>
192	Rufous Nightheron	<i>Nycticorax caledonicus</i>
179	*Sacred Ibis	<i>Threskiornis aethiopica</i>
180	*Straw-necked Ibis	<i>Threskiornis spinicollis</i>
182	*Yellow-billed Spoonbill	<i>Platalea flavipes</i>
205	Plumed Whistling-duck	<i>Dendrocygna eytoni</i>
203	Black Swan	<i>Cygnus atratus</i>
207	Australian Shelduck	<i>Tadorna tadornoides</i>
208	*Pacific Black Duck	<i>Anas superciliosa</i>
211	*Grey Teal	<i>Anas gibberifrons</i>
212	Australasian Shoveler	<i>Anas rhynchotis</i>
213	Pink-eared Duck	<i>Malacorhynchus membranaceus</i>
202	*Maned Duck	<i>Chenonetta jubata</i>
232	*Black-shouldered Kite	<i>Elanus notatus</i>
229	Black Kite	<i>Milvus migrans</i>
228	Whistling Kite	<i>Haliastur sphenurus</i>
221	*Brown Goshawk	<i>Accipiter fasciatus</i>
222	*Collared Sparrowhawk	<i>Accipiter cirrhocephalus</i>
224	Wedge-tailed Eagle	<i>Aquila audax</i>
225	Little Eagle	<i>Hieraaetus morphnoides</i>
218	Spotted Harrier	<i>Circus assimilis</i>
238	Black Falcon	<i>Falco subniger</i>
237	*Peregrine Falcon	<i>Falco peregrinus</i>
235	*Australian Hobby	<i>Falco longipennis</i>
239	*Brown Falcon	<i>Falco berigora</i>
240	*Australian Kestrel	<i>Falco cenchroides</i>
009	*Stubble Quail	<i>Coturnix pectoralis</i>
018	Little Button-quail	<i>Turnix velox</i>
133	*Masked Lapwing	<i>Vanellus miles</i>
135	*Banded Lapwing	<i>Vanellus tricolor</i>
144	*Black-fronted Plover	<i>Charadrius melanops</i>
957	*Feral Pigeon	<i>Columba livia</i>
030	*Peaceful Dove	<i>Geopelia placida</i>
031	Diamond Dove	<i>Geopelia cineata</i>
043	*Crested Pigeon	<i>Ocyphaps lophotes</i>

2/.. BIRD SPECIES LIST continued.....

273 *Galah	<i>Cacatua roseicapilla</i>
269 Sulphur-crested Cockatoo	<i>Cacatua galerita</i>
277 *Superb Parrot	<i>Polytelis swainsonii</i>
274 *Cockatiel	<i>Nymphicus hollandicus</i>
310 Budgerigar	<i>Melopsittacus undulatus</i>
288 *Eastern Rosella	<i>Platycerus eximius</i>
295 *Red-rumped Parrot	<i>Psephotus haematonotus</i>
297 *Blue-bonnet	<i>Northiella haematogaster</i>
337 *Pallid Cuckoo	<i>Cuculus pallidus</i>
338 *Fan-tailed Cuckoo	<i>Cuculus pyrrhophanus</i>
341 Black-eared Cuckoo	<i>Chrysococcyx osculans</i>
342 *Horsfield's Bronze-cuckoo	<i>Chrysococcyx basalis</i>
242 *Southern Boobook	<i>Ninox novaeseelandiae</i>
249 *Barn Owl	<i>Tyto alba</i>
313 *Tawny Frogmouth	<i>Podargus strigoides</i>
317 *Australian Owlet Nightjar	<i>Aegotheles cristatus</i>
335 Fork-tailed Swift	<i>Apus pacificus</i>
322 *Laughing Kookaburra	<i>Dacelo novaeguineae</i>
325 Red-backed Kingfisher	<i>Halcyon pyrrhopygia</i>
326 *Sacred Kingfisher	<i>Halcyon sancta</i>
329 *Rainbow Bee-eater	<i>Merops ornatus</i>
318 *Dollarbird	<i>Eurystomus orientalis</i>
357 *Welcome Swallow	<i>Hirundo neoxena</i>
359 *Tree Martin	<i>Cecropis nigricans</i>
647 *Australian Pipit	<i>Anthus novaeseelandiae</i>
424 *Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>
425 Ground Cuckoo-shrike	<i>Coracina maxima</i>
430 *White-winged Triller	<i>Lage sueurii</i>
381 *Red-capped Robin	<i>Petroica goodenovii</i>
385 *Hooded Robin	<i>Melanodryas cucullata</i>
392 Eastern Yellow Robin	<i>Eopsaltria australis</i>
377 *Jacky Winter	<i>Microeca leucophaea</i>
416 Crested Shriketit	<i>Falcunculus frontatus</i>
398 *Golden Whistler	<i>Pachycephala pectoralis</i>
401 *Rufous Whistler	<i>Pachycephala rufiventris</i>
408 *Grey Shrike-thrush	<i>Colluricincla harmonica</i>
369 *Restless Flycatcher	<i>Myiagra inquieta</i>
361 *Grey Fantail	<i>Rhipidura fuliginosa</i>
364 *Willie Wagtail	<i>Rhipidura leucophrys</i>
443 *Grey-crowned Babbler	<i>Pomatostomus temporalis</i>
509 *Rufous Songlark	<i>Cinclorhampus mathewsi</i>
508 *Brown Songlark	<i>Cinclorhampus cruralis</i>
504 Speckled Warbler	<i>Sericornis sagittata</i>
465 Weebill	<i>Smicrornis brevirostris</i>
463 *Western Gerygone	<i>Gerygone fusca</i>
476 Inland Thornbill	<i>Acanthiza apicalis</i>
481 Chestnut-rumped Thornbill	<i>Acanthiza uropygialis</i>
486 *Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>
471 *Yellow Thornbill	<i>Acanthiza nana</i>
466 *Southern Whiteface	<i>Aphelocephala leucopsis</i>
549 Varied Sittella	<i>Daphoenositta chrysoptera</i>
555 *Brown Treecreeper	<i>Climacteris picumnus</i>
640 *Spiny-cheeked Honeyeater	<i>Acanthagenys rufogularis</i>

3/ BIRD SPECIES LIST continued....

585 *Striped Honeyeater	Plectorhyncha lanceolata
645 Noisy Friarbird	Philemon corniculatus
646 *Little Friarbird	Philemon citroegularis
641 *Blue-faced Honeyeater	Entomyzon cyanotis
634 *Noisy Miner	Manorina melanocephala
635 *Yellow-throated Miner	Manorina flavigula
625 *White-plumed Honeyeater	Lichenostomus penicillatus
580 Black-chinned Honeyeater	Melithreptus gularis
583 *Brown-headed Honeyeater	Melithreptus brevirostris
598 Painted Honeyeater	Grantiella picta
449 Crimson Chat	Epthianura tricolor
448 *White-fronted Chat	Epthianura albifrons
564 *Mistletoebird	Dicaeum hirundinaceum
565 Spotted Pardalotus	Pardalotus punctatus
976 *Striated Pardalotus	Pardalotus striatus
574 *Silvereye	Zosterops lateralis
995 *House Sparrow	Passer domesticus
652 Diamond Firetail	Emblema guttata
653 *Zebra Finch	Poephila guttata
655 Double-barred Finch	Poephila bichenovii
999 *Common Starling	Sturnus vulgaris
671 Olive-backed Oriole	Oriolus sagittatus
693 *White-winged Chough	Corcorax melanprhamphos
675 *Apostlebird	Struthodea cinerea
415 *Magpie-lark	Grallina cyanoleuca
544 Masked Woodswallow	Artamus personatus
545 *White-browed Woodswallow	Artamus superciliosus
546 *Black-faced Woodswallow	Artamus cinereus
547 Dusky Woodswallow	Artamus cyanopterus
702 Grey Butcherbird	Cracticus torquatus
700 *Pied Butcherbird	Cracticus nigrogularis
705 *Australian Magpie	Gymnorhina tibicen
694 Pied Currawong	Strepera graculina
930 *Australian Raven	Corvus coronoides
954 *Little Raven	Corvus mellori

numbered as per RAOU species list.

Attachment 2. Main Plant Species found around the Project Site.

TREES

Western Grey Box	<i>Eucalyptus microcarpa</i>
Yellow Box	<i>Eucalyptus melliodora</i>
Bimble Box	<i>Eucalyptus populnea</i>
White Cypress Pine	<i>Callitris glaucophylla</i>
Bull-oak	<i>Allocasuarina luehmannii</i>
Rosewood	<i>Heterodendrum oleifolium</i>
Wilga	<i>Geijera parviflora</i>
Kurrajong	<i>Brachychiton populneus</i>

SHRUBS

Streaked Wattle	<i>Acacia lineata</i>
Western Silver Wattle	<i>Acacia decora</i>
Yarran	<i>Acacia homalephylla</i>
Weeping Myall	<i>Acacia pendula</i>
Desert Cassia	<i>Cassia eremophila</i>
Budda	<i>Eremophila mitchelli</i>
Wedge-leaf Hop-bush	<i>Dodonaea cuneata</i>
Lobed Hop-bush	<i>Dodonaea lobulata</i>
Waterbush	<i>Myoporum montanum</i>

GROUND COVER

Amulla	<i>Myoporum debile</i>
Australian Bugle	<i>Ajuga australis</i>
Rock Fern	<i>Cheilanthes tenuifolia</i>
Nardoo	<i>Marsilea drummodii</i>
Small Vanilla Lily	<i>Arthropodium minus</i>
Climbing Saltbush	<i>Rhagodia nutans</i>
Prickly Roly-poly	<i>Salsola kali</i>
Galvanized Burr	<i>Sclerolaena birchii</i>
Grey Copperburr	<i>Sclerolaena diacantha</i>
Cotton-bush	<i>Maireana aphylla</i>
Tar Vine	<i>Boerhavia diffusa</i>
Pussy-tails	<i>Ptilotus spathulatus</i>
Poison Pea	<i>Swainsona microphylla</i>
Australian Cranesbill	<i>Geranium solanderi</i>
Grassland Cranesbill	<i>Geranium retrorsum</i>
Blue Crowsfoot	<i>Erodium crinitum</i>
Wonga wonga Vine	<i>Pandorea pandorana</i>
Annual Bluebell	<i>Wahlenbergia gracilentia</i>

Parasites

Box Mistletoe	<i>Amyema miqueli</i>
Grey Mistletoe	<i>Amyema quandang</i>

Attachment 3.

Bird species for which the re-vegetation could be targeted.

(a) The following species have all been affected by habitat alteration and clearance. Some of the species are considered endangered within NSW, with the Superb Parrot now considered endemic to this state, being extinct within Victoria.

1. Superb Parrot

Frith & Calaby (1953) in their review of the Superb Parrot considered that numbers would stabilise, as agricultural development had reached its peak. This was found not to be true and the species has continued to reduce in population. This was considered to be caused by (1) habitat clearing both at breeding and feeding sites; (2) illegal trapping was believed to be also impacting on numbers. Schrader (1980) reviewed the species central-west distribution and identified that one population existed and not two as previously thought, with the northern population really being the alleged southern population on migration. Sightings confirmed this. Webster (1988) recently under the guidance of the Australian National Parks Service studied the species breeding distribution. It is considered that unless breeding and feeding habitat is protected then the species will continue to reduce in numbers. Further research is still continuing to establish conservation measures required to halt the declining population, with the species being considered endangered by the N.S.W. National Parks and Wildlife Service.

Identified food source :-

River Red Gum - blossom, seed, lerps  
Bimble Box - blossom, lerps  
Yellow Box - blossom, seed, lerps  
Grey Box - blossom, lerps(?)  
Yarran - seed  
Weeping Myall - blossom, seed  
Grey Mistletoe Amyema quandang - blossom, fruit.  
Box Mistletoe A. miquelli - blossom fruit.  
grasses - Whitetop  
- Barley Grass  
- Rumex sp.  
- Salsola kali  
- wheat

2. Painted Honeyeater

Little is known about the status of this species except that it is rare within the region. The species erupts into areas usually during seasons when mistletoe is in flower. The clearing of large tracts of woodland has reduced this species food source.

Food source :-

- Weeping Myall - Grey Mistletoe fruit  
- River Red Gum - Box Mistletoe fruit

Attachment 3/.... continued

3. Bush Stone-curlew

The introduction of the fox and habitat clearing has been blamed for the disappearance of this species. The species can still be found in some woodland areas within the district.

Food source :-

insects, lizards and small animals.

(c) Other species which have been reduced but still maintain viable populations and would benefit from re-vegetation :

1. Hooded Robin
2. Red-capped Robin
3. Ground Cuckoo-shrike
4. Peregrine Falcon
5. Black Falcon
6. Little Eagle
7. Black-chinned Honeyeater
8. Blue-faced Honeyeater
9. Grey-crowned Babbler
10. Grey Butcherbird
11. Jacky Winter
12. Inland Thornbill
13. Speckled Warbler.

#### Attachment 4. CORRIDORS/RE-VEGETATION

A).

Habitat corridors have been outlined on Figure 20., so as to achieve the following :-

1. re-establish woodland habitat;
2. provide feeding and movement routes for wildlife;
3. provide shelter and a food source for selected species;
4. to represent a good selection of the flora and fauna found within the area.
5. reduce noise output from the mining site;
6. arrest dust developing from the mining site;
7. preserve the current woodland effect of the mining site;

Additionally surrounding farmers should be encouraged to provide secondary woodland corridors to further strengthen the corridors outlined and neutralise the perceived effects of the mining activities. This could be done by :-

1. the mine forester providing practical advice to the local farmers;
2. provision of trees and shrubs;

B).

Suggested vegetation structure to re-establish original vegetation and provide a food source and shelter for species as per Attachment 1 and Attachment 3.

The woodland is of that type referred to as Sub-humid Woodland. The following list of flora is compiled from habitat samples taken from woodland around the project site. Indicated also is the position each species occupies within that eco-system.

##### Trees

- Grey Box *Eucalyptus microcarpa* - dominate tree  
White Cypress Pine *Callitris glaucophylla* - mixed either as thickets or scattered trees  
Yellow Box *Eucalyptus melliodora* - scattered trees  
Bimble Box *Eucalyptus populnea* - dominate tree between creek line and Grey Box woodland.  
River Red Gum *Eucalyptus camaldulensis* - along watercourses.  
Rosewood *Heterodendrum oleifolium* - scattered trees  
Wilga *Geijera parviflora* - scattered trees  
Bull-oak *Allocasuarina luehmanni* - clumps usually associated with gilgai country.  
Hooked Needlewood *Hakea tephrosperma* - scattered clumps around parent tree.  
Kurrajong *Brachychiton populneus* - scattered tree.  
Cherry Ballart *Exocarpos cupressiformis* - individual trees  
Sweet Quandang *Santalum acuminatum* - scattered clumps.  
Weeping Pittosperum *Pittosperum phillyreoides* - scattered trees.  
Yarran *Acacia homalophylla* - clumps.

2/ Corridors and re-vegetation continued.....

Weeping Myall *Acacia pendula* - scattered trees or thickets.

Undergrowth

Warrior Bush *Apophyllum anomalum* - scattered shrubs.

Streaked Wattle *Acacia lineata* - dominate undergrowth.

Western Silver Wattle *Acacia decora* - clumps.

Lobed Hop-bush *Dodonaea lobulata* - scattered shrubs.

Wedge-leaf Hop-bush *Dodonaea cuneata* - scattered often in clumps.

Water Bush *Myoporum montanum* - scattered shrubs.

Desert Cassia *Cassia eremophila* - scattered shrubs.

Budda *Eremophila mitchelli* - scattered shrubs.

Ground Cover.

Amulla *Myoporum debile* - scattered under Grey Box.

REFERENCES

Frith, H. J. and Calaby J. H. (1953). The Superb Parrot in southern New South Wales. *Emu*, 53:324-330.

Schrader, N. W. (1980). A review on the distribution of the Superb Parrot in central New South Wales. *Australian Birds*, 14:3:45-50.

Webster, R. (1988). The Superb Parrot, a survey of the breeding distribution and habitat requirements. Australian National Parks and Wildlife Service, Canberra.

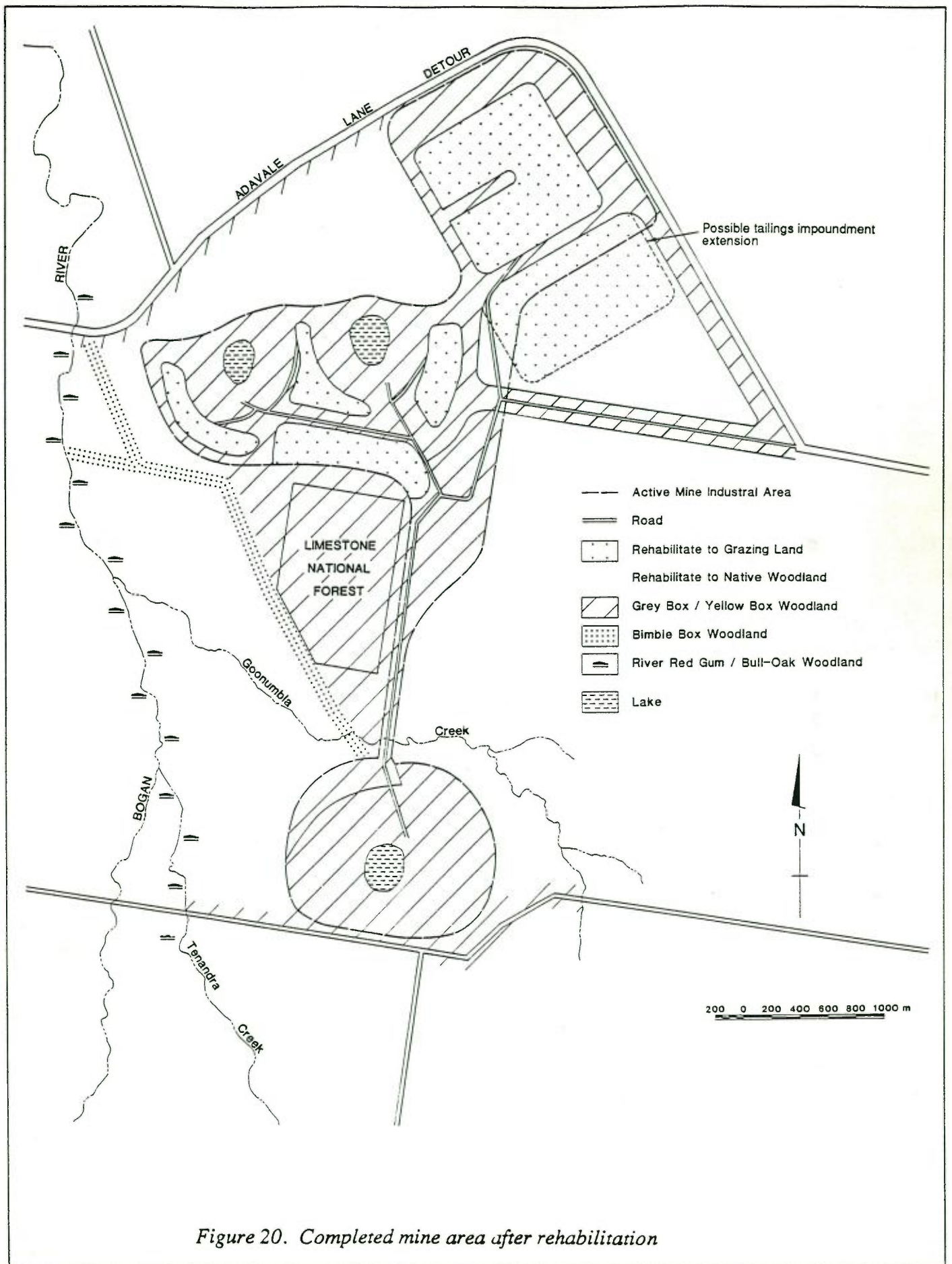


Figure 20. Completed mine area after rehabilitation

**APPENDIX E**

**ARCHAEOLOGICAL STUDY**

ANU Archaeological Consultancies  
ANUTECH Pty. Ltd.

**AN ARCHAEOLOGICAL SURVEY OF THE  
GOONUMBLA PROJECT AREA**

by

Tim Stone

A report to Natural Systems Research Pty Ltd

ANU Archaeological Consultancies  
ANUTECH PTY LTD  
GPO BOX 4  
Canberra City 2601

February 1986

## TABLE OF CONTENTS

	Page
1. Introduction	1
2. Environmental Setting	1
3. Types of Sites	2
4. Previous Archaeological Investigations	4
5. Survey Methods	5
6. Results and Discussion	6
7. Legislation Pertaining to Aboriginal Sites in New South Wales	8
8. Assessment of Significance	9
8.1 Aboriginal Significance	10
8.2 Scientific Significance	11
9. Recommendations	13
10. Reference	15
Appendix A	
Appendix B	

## 1. INTRODUCTION

This report details the results of a reconnaissance for archaeological sites in the area of the Goonumbla project area, 20 km southwest of Peak Hill, NSW. Peko-Wallsend propose to extract gold and copper from three locations within this lease, designated Endeavour 22, 26 and 27 (Figure 1). The purpose of this investigation was to:

1. locate and record any Aboriginal archaeological sites within the area of the project area,
2. recommend measures to mitigate any potential damage to archaeological sites,
3. liaise with the local Aboriginal community to ascertain their views on the proposed development.

Fieldwork was undertaken in late January, 1986 by Tim Stone, from A.N.U. Archaeological Consultancies and Ken Robinson from the Peak Hill Local Aboriginal Land Council. Wayne O'Neill, a company geologist, accompanied the field team for half a day, and organised access to properties with the relevant land-holders.

## 2. ENVIRONMENTAL SETTING

The Goonumbla project area is an area of approximately 6km x 5km situated at the headwaters of the Bogan River. The country is generally flat to gently undulating and remnants of box, gum and native pine suggest that the area supported an open savannah woodland before clearing.

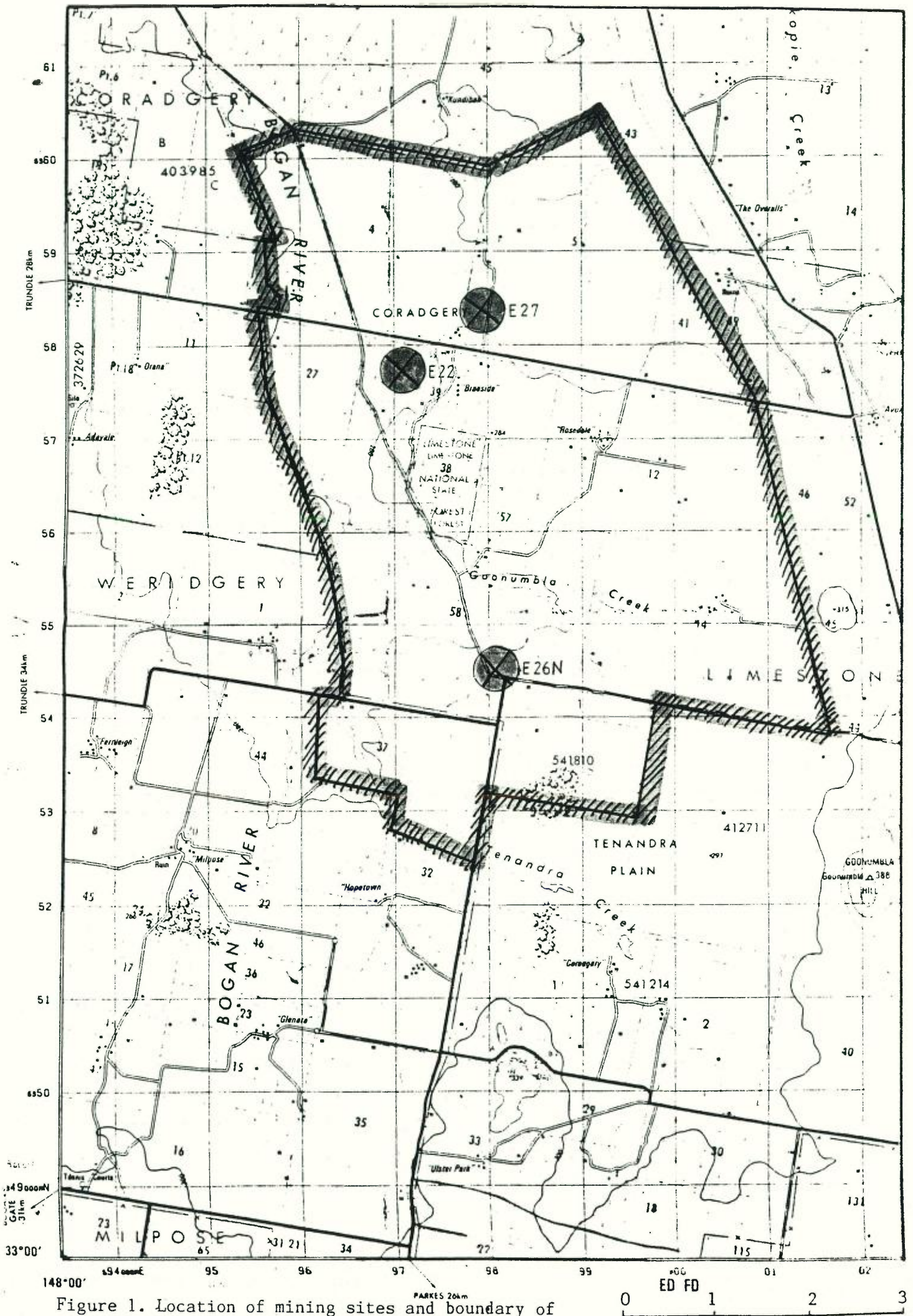


Figure 1. Location of mining sites and boundary of mining area.

Geologically, most of the study area is composed of Silurian volcanics (mostly Andesite and Monzonite). The soils produced from the weathering of these rock-types are red/brown earths and cracking clays. These dominate the surface of the study area and have been ploughed near the Bogan River. Outcrops of the volcanic parent material are confined mostly to the area around the Limestone National Forest in the centre of the study area. Large rounded sandstone slabs and cobbles are found dispersed or in clusters on the soil surface. These are residual and probably owe their origin to overlying Devonian strata now eroded away.

The main waterway is the Bogan River which forms the western boundary of the study area. Two tributaries within the study area are Goonumbla Creek and Tenandra Creek. These streams have ceased to flow since clearance of the land for agriculture and subsequent soil erosion. A series of depressions in the clay soil know as "gilgai" are located on the southern boundary of the study area. These depressions hold fresh clean water for a short period after rains.

### 3. TYPES OF SITES

The type of Aboriginal sites that occur in New South Wales are described in a pamphlet for planners and developers produced by the National Parks and Wildlife Service in 1979 (copy enclosed). The sites that might occur in the Goonumbla area are described below.

#### Shell Middens

These range in thickness from thin scatters to stratified deposits of shell and sediment up to 2m thick. In addition to shell which has accumulated as food refuse, shell middens usually contain other food remains such as bone from fish, birds and terrestrial animals and humus from the decay of plant and animal remains. They also commonly contain charcoal and artefacts made from stone, shell and bone.

In western NSW the major shellfish species likely to occur in middens are the two freshwater mussels Velesunio ambiguus and Alathyria jacksonii.

### **Scatters of Stone Artefacts**

These usually occur as surface scatters and sometimes contain charcoal and bone fragments. Where such sites are buried by sediment they will not be detected unless exposed by erosion or disturbed by human activities such as logging, road construction or ploughing.

Scatters of stone artefacts representing campsites may be found anywhere where the ground surface is relatively flat, especially close to sources of drinking water such as creeks or soaks. Isolated artefacts may be found anywhere in the landscape.

### **Stone Quarries**

The raw material used for making flaked or ground stone artefacts may have been quarried from surface outcrops or picked up as loose rock on the surface. In the study area the only possible sources of raw material are the residual sandstone cobbles, referred to in Section 2. These may include elements of chert, mudstone, silcrete and quartz.

### **Scarred Trees**

Slabs of bark were cut from trees by Aboriginal people and used for a variety of purposes, including roofing shelters and constructing canoes, shields and containers. Scars also resulted from the cutting of toe holds for climbing trees to obtain honey or to capture animals such as possums. The classification of scarred trees as natural, European or Aboriginal is largely a subjective process, however, if the scar is prehistoric the tree must now be more than 120 years old.

## **Stone Arrangements, Ceremonial Grounds and Natural Sacred Sites**

Stone arrangements range from simple cairns or piles of rock to more elaborate arrangements; patterns of stone laid out to form circles and other designs, or standing slabs of rock held upright by stones around the base. Some stone arrangements were used in ceremonial activities whilst others may represent sacred or totemic sites. Other 'sites' associated with the religious side of Aboriginal life are those now called 'sacred natural or mythological sites'. These are natural features in the landscape; rock outcrops, waterholes, mountains, which were associated with initiation ceremonies and/or the activities of the culture heroes or dreamtime creators.

### **Burial Grounds**

Aboriginal burial grounds may consist of a single interment or a suite of burials. Outside the study area burials have been reported from several sites. These sites have been reported to the National Parks and Wildlife Service and are all located in sandy deposits adjacent to the Bogan River. This pattern of burial location is similar to other rivers in south east Australia.

### **Carved Trees**

Carved trees have been reported from outside the study area and are thought to have a wide distribution in south east Australia. Some carved trees are associated with burials whilst others may be sacred or totemic sites.

## **4. PREVIOUS ARCHAEOLOGICAL INVESTIGATIONS**

No systematic archaeological surveys have been undertaken anywhere along the Bogan River. However, the National Parks and Wildlife Site register lists 31 sites in the upper Bogan region, to the north of the study area.

These are listed in Appendix A, and include:

18	Carved trees (4 with burials)
3	Scarred trees
3	Quarry sites
2	Open campsites
2	Rockshelters with art
1	Axe grinding groove
1	Burial
1	Stone arrangement

With the exception of the 3 quarries and the stone arrangement, all known sites are located along the Bogan River and its tributaries.

## 5. SURVEY METHODS

The location of an archaeological site in a semi-arid environment is usually very strongly influenced by the availability of fresh-water. Site types such as scatters of stone tools representing open camp sites are often found in close association with sources of permanent or semi-permanent water. Other site types such as stone arrangements, quarries or scarred trees may be found anywhere in the landscape. For this reason it was determined that the survey should focus on parts of the project area nearest to likely water sources, and that areas away from the water sources should be sampled. These latter areas include the mining sites designated E22, E26N and E27. Figure 2 highlights the areas covered during the survey.

On the first day, the survey was restricted to areas of public access i.e. the major gravel roads linking the various land-holdings. Roadside strips up to 40m wide on either side of these roads, and related exposures within the study area were given full coverage. In the strips either side of the road between "Avondale" and Trundle, much of the ground surface remained relatively undisturbed with a visibility of about 30%. Other roadside strips in the area were narrower and the ground surface was either obscured by road gravel or disturbed by ditches.

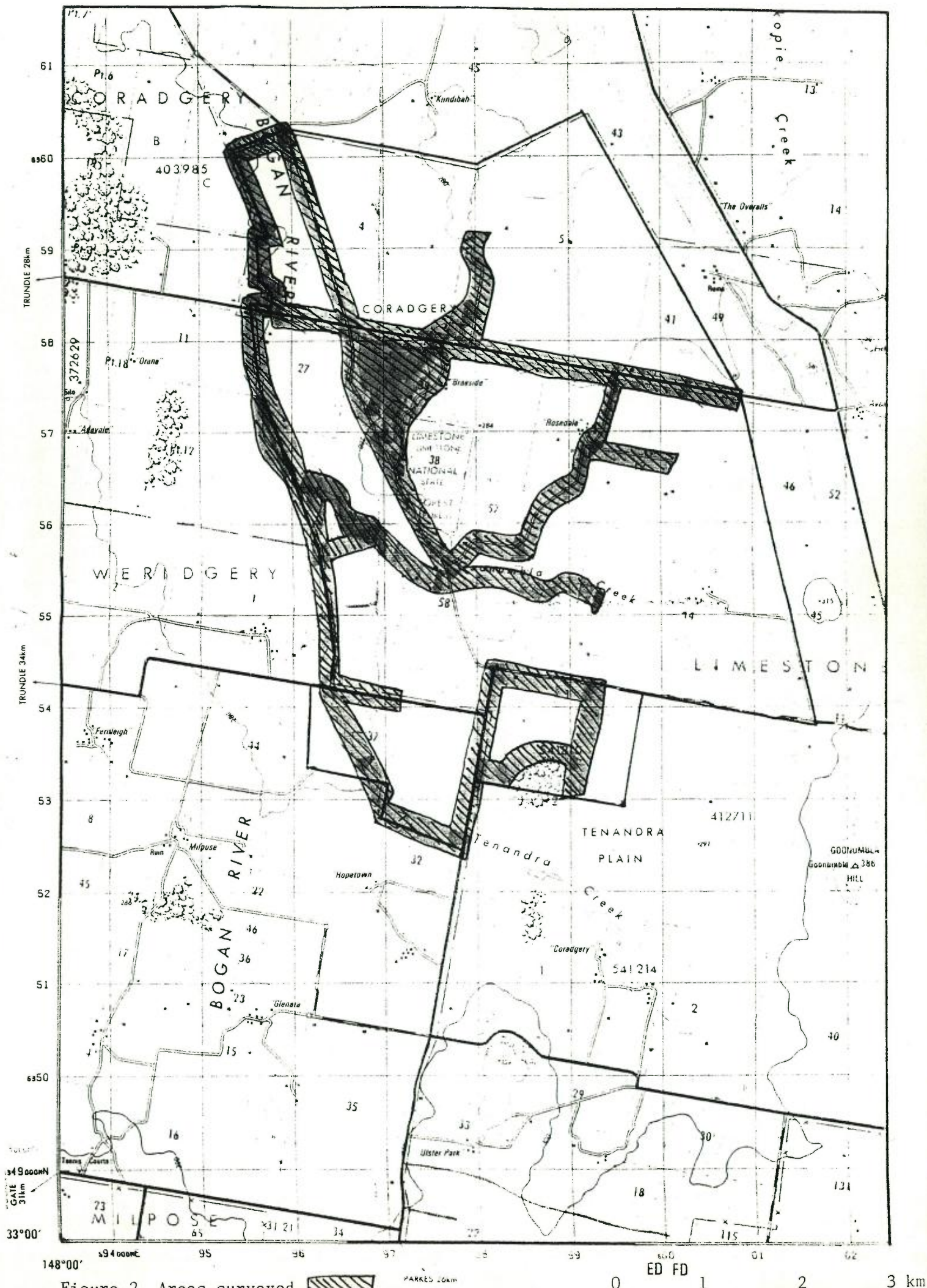


Figure 2. Areas surveyed.

Remnants of the original vegetation occurring along these strips were also examined for carved or scarred trees.

Once permission had been obtained to enter the relevant properties within the study area, the survey was extended to include the remaining tracks and exposures, especially those near the mining sites, and the major drainage lines i.e. the Bogan River, Goonumbla Creek and Tenandra Creek. It was also thought that the "gilgai" might have an archaeological association, so this was examined also.

All surveying was done on foot by the two team members walking generally 50m apart. They inspected all trees that were encountered (usually box) and all areas where the ground was exposed. Surface visibility was usually high as large proportions of the study area had been either ploughed or exposed by grazing and the movement of stock and vehicles.

## 6. RESULTS AND DISCUSSION

A total of 16 sites were located during the survey (Figure 3). Among these sites 13 are open scatters of stone artefacts, one is an open scatter of stone artefacts associated with a scarred tree, and one is an isolated find. These are described fully in Appendix B. Fifteen of these are located along the Bogan River and its two tributaries in the study area, seven of which are located within 1km of the confluence of Goonumbla Creek and the Bogan River. One site is associated with the "gilgai" at the southern boundary. No sites were located away from sources of permanent or semi-permanent water. None were located in the high impact areas designated E22, E26 and E27.

Overall, the sites located in the Goonumbla project area were small and in poor condition. Only in the case of Site 3 (Appendix B) was the area of a site more than 50m x 50m and this site only contained 28 artefacts. The average number of artefacts in each site was only 7.5 and the density of artefacts at each site was very low. The low density and poor condition of the sites can be partly explained by erosion and the

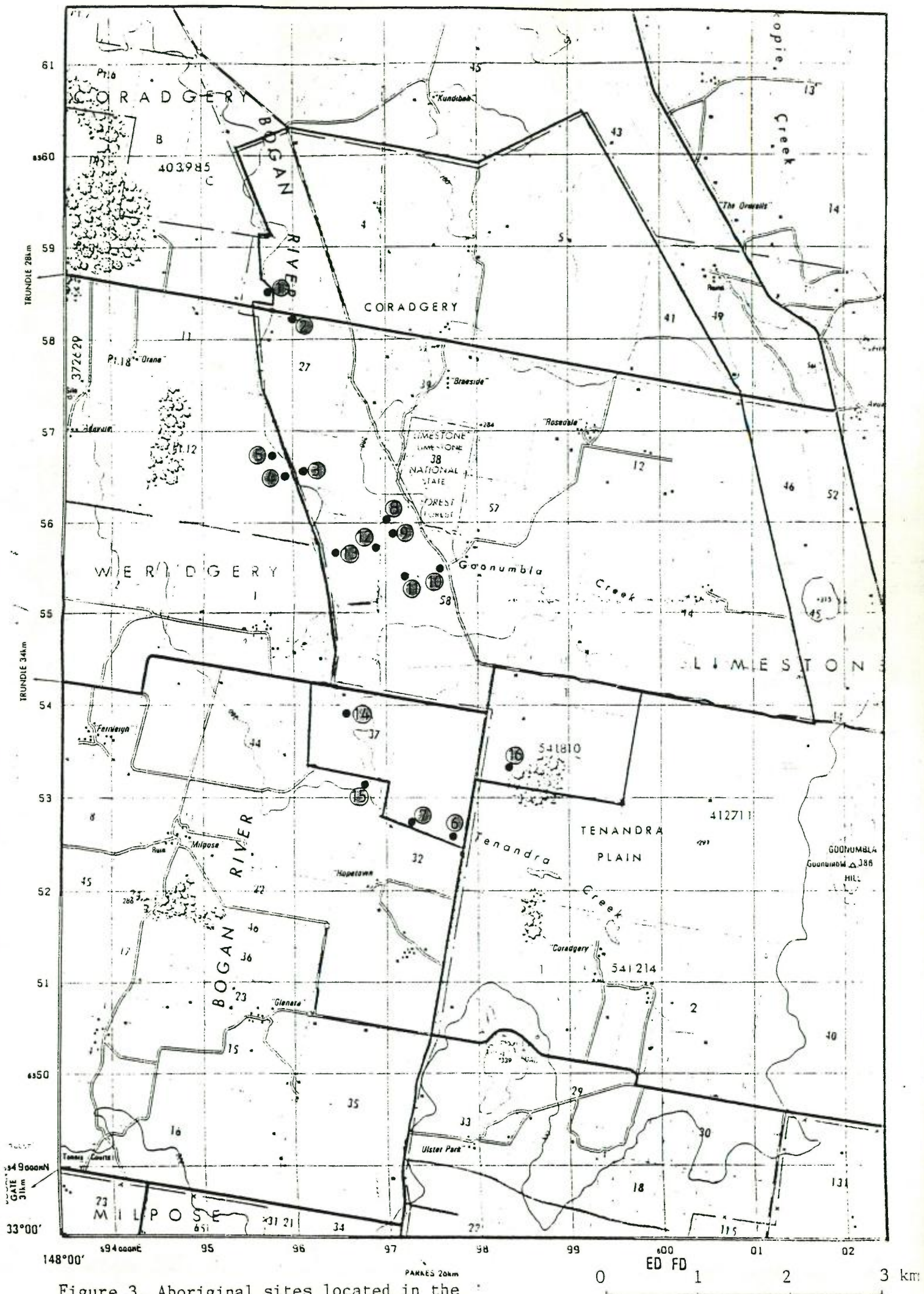


Figure 3. Aboriginal sites located in the archaeological survey.

dispersal of artefacts following disturbance of the soil by ploughing, overgrazing and the movement of stock and vehicles.

The sites recorded during the survey displayed a variety of artefact types. These included flakes with retouch and usewear, two polished edge-ground axes, one horse-hoof core and one backed blade. These were made on a variety of raw materials including chert, silcrete, quartz, quartzite and indurated mudstone. The axes were made of volcanic tuff. Quartz dominated the assemblages at Sites 3, 5, and 9. The type of silcrete used for stone tool manufacture was identified as "greybilly".

A possible source of most of the raw materials is the residual cobbles. However, no conclusive signs of quarrying were detected. This kind of interpretation was made difficult because many of the residual features have been ploughed over. Of the 16 sites recorded, none have been unaffected by European land-use activities.

The level of ground-surface visibility in the study area generally was high. It can be confidently stated therefore, that the site distribution map presented in Figure 3 is a good reflection of the prehistoric settlement pattern. From this it is evident that the riverine environment was a focus of Aboriginal economic activity in the area. The vicinity of the confluence of the Bogan River and Goonumbla Creek appears to have been particularly popular, and probably provided the most reliable water supply during dry seasons.

Seasonal wetlands such as those formed in "gilgais" probably permitted occupation of areas away from the major rivers and streams. This is indicated by the scatter of stone artefacts at Site 16, and suggests that similar archaeological sites will be located around "gilgais" elsewhere in the region.

## 7. LEGISLATION PERTAINING TO ABORIGINAL SITES IN NEW SOUTH WALES

There are two Acts of the New South Wales Parliament pertaining to Aboriginal sites; the **National Parks and Wildlife Act, 1974** and the **Environmental Planning and Assessment Act, 1979**, and regulations, 1980. A detailed account of the legislation and its interpretation has been presented by Bowdler (1983:11-17).

The National Parks and Wildlife Service's policy with respect to developers is that they should consult with the Service as early as possible about potential impact on Aboriginal sites so that long term planning is feasible. Service policy is set out in the Service booklet of 1979 entitled **For Planners and Developers: Aboriginal Sites in New South Wales**. The most important provision in the National Parks and Wildlife Act is Section 90 which states, in part,

'A person who, without first obtaining the written consent of the Director, knowingly destroys, defaces or damages a relic or Aboriginal place is guilty of an offence against this Act.'

When sites are identified in an area of proposed development, and where they might be affected by the development, several options are possible. These might be summarised as destruction, destruction with mitigation, or preservation. Preservation is often made possible by modifying the development slightly. If damage or destruction is inevitable and the site is deemed to be of value but not to be worthy of protection at any cost, some form of mitigation of its destruction may be warranted. This might take the form of a detailed recording of the site, or a collection of artefacts exposed on the ground surface, or excavation of stratified archaeological deposits. If the site is deemed to be 'insignificant' it may simply be allowed to be destroyed without further action.

The Environmental Planning and Assessment Act, 1979 recognises the need to protect the cultural and natural heritage of New South Wales. It compliments the National Parks and Wildlife Act, 1974 in that it provides

for planning before development and it **obliges** the developer to consult persons with relevant expertise and experience (Bowdler 1983:14). Under Part V of the Act, in an environmental impact statement consideration is to be given to the likely impact of an activity on the environment, including whether that activity may cause-

- d) a diminution of the aesthetic, recreational, scientific or other environmental quality or value of a locality.
- e) any effect upon a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations.

The heritage scope of this legislation is wider than that of the **National Parks and Wildlife Act, 1974**, and there is no doubt that sites of significance to contemporary Aborigines are included.

The Federal Government has enacted the **Aboriginal and Torres Strait Islander Heritage (Interim Protection) Act 1984** to preserve and protect areas and objects of particular significance to Aborigines in accordance with Aboriginal tradition. The major purpose of the Act is to allow preservation or protection of significant Aboriginal areas and objects.

This Act is not intended to exclude or limit the operation of State Acts of Parliament pertaining to heritage protection, rather it is capable of operating concurrently with such Acts. After two years, that is from June 1986, this Act will cease to operate unless sooner repealed.

## **8. ASSESSMENT OF SIGNIFICANCE**

The concept of significance is broad and complex. "The heritage value of a site encompasses its aesthetic, historic, scientific and social significance for future generations as well as for the present community" (Australian Heritage Commission Act 1975 S 4(1)). In discussing

individual archaeological sites or groups of sites it is important to realise that there are several ways to view significance. Bowdler (1983) categorizes significance under several categories: Aboriginal, Public, Historical, Aesthetic, Educational and Scientific.

Often it is not possible to assess the significance of sites according to individual categories alone. Many sites are significant under several criteria. Sites which are significant to the discipline of archaeology are also significant to Aboriginal people, and sites which have aesthetic value may also have educational significance. Despite this inter-relationship, it is normal to discuss each of the significance categories under separate headings. Only the categories of Aboriginal and Scientific significance are relevant to the sites discovered in the survey.

### **8.1 Aboriginal Significance**

The Wiradjuri Aboriginal people living in the Peak Hill region are concerned about any development which may affect Aboriginal sites in the area. Ken Robinson a Sites Officer with the Peak Hill Local Aboriginal Land Council participated in the survey and discussions were held with him during our time in the field.

Ken stated that the Goonumbla project area was not significant to the local Aboriginal Community. He said that sites usually significant to local Aborigines such as burials and rockshelters with art were not likely to be found here.

He also stated that the archaeological sites that were located during the survey are of limited value because they have been damaged by agricultural activities.

He did however, state that knowledge of the location of these sites and their general characteristics was significant on educational grounds. The local school at Peak Hill is introducing Aboriginal Studies into their curriculum and therefore knowledge of the sites, their location and

contents provides a valuable aid for teaching Aboriginal culture and prehistory. For this reason, Ken has requested a copy of this report.

## 8.2 Scientific Significance

Two kinds of framework are suitable for assessing the scientific/archaeological significance of Aboriginal sites. The first of these involves assessing the research potential of each individual site and the second involves assessing its representativeness; that is, the value of the site in relation to other sites in the region (Bowdler 1983). One aim of any heritage conservation programme is to conserve for future research representative samples from different environments all classes of archaeological sites. Representativeness also takes into account how common a site is, "If a site is unique in some way, it is ipso facto significant" (Bowdler 1984).

With the exception of one scarred tree and one isolated find all of the sites discovered during the survey were open campsites represented by scatters of stone artefacts. This type of site is most commonly assessed in terms of its scientific significance alone, and initially their individual research potential will be discussed. Three related aspects of a site, its integrity, its structure and its contents, will be considered before discussing representativeness.

1. **Site Integrity:** This refers to how well preserved or how badly disturbed a site is. Much of site-oriented archaeological research is focussed on the pattern and distribution of artefacts in relation to one another, and the sites with the highest value are those where each artefact is lying exactly where it was originally dropped. In a region such as the Goonumbla project area the landscape in which the sites are located has been cleared, and many of the sites have been ploughed several times. Most have been further disturbed by road building, vehicle traffic and the repeated traffic of hooved animals. Many have been exposed to wind and water erosion which in several cases has totally destroyed the integrity of sites. An additional potential problem exists in the possibility that the area has been frequented by amateur

collectors. Since the artefacts have been exposed, it is highly possible that the larger and more easily recognised artefact types, such as grindstones have been removed in the past. Grindstones were notably absent at the sites recorded in the Goonumbla area. Consequently the surface scatter sites recorded during this survey all rate LOW on "site integrity" significance criteria.

2. **Site Structure:** This refers to whether or not the site is stratified, how large it is, etc. As a general rule to thumb, sites which are stratified (that is, have several buried layers of occupation) are of more potential research value than sites which have only a single layer. This is because they provide evidence of changes and continuity in a culture over time, a topic in which most archaeologists are interested. Also, large sites tend to have more research potential than small sites. However, in both stratification and size, these rules of thumb are not always true. Some research projects might require that sites be both single layers of occupation and small in size. Depending upon the condition of the site's integrity, these types of sites might provide evidence which will help to reconstruct an "event" in prehistory. This is something that is generally impossible with larger sites where concentrations of cultural materials may be superimposed over time and where separate events are confused by the mass of information.

The sixteen surface scatter sites recorded in the survey were located in badly eroded or ploughed soils and none appeared to be stratified. If any stratification did exist in parts of the sites not currently exposed, ploughing would have destroyed its integrity in virtually every case. Consequently the sixteen open campsites rate LOW on "site structure" significance criteria.

3. **Site Contents:** This aspect of significance deals with the types of cultural materials which are found within a site. Integrity and structure aside, the types of artefacts found at a site are an important facet of whether or not it is considered valuable for research purposes.

The original cultural materials of the sites recorded in the survey have been exposed to weathering. No bones or other organic artefacts are preserved, and only imperishable stone artefacts remain. The stone artefacts are valuable for some types of studies, although the lack of site integrity severely limits the types of research which can be done. As most of the sites located in the Goonumbla project area are small and the number of artefacts limited, **they rate low according to site content significance criteria.**

4. **Representativeness:** No matter what value is given to an individual site itself, it may assume considerable importance when placed in its regional context. One of the most important aspects of a site's value is the frequency of sites of this type.

On the basis of this survey and site information held by the National Parks and Wildlife Service, there is likely to be a great number of open camp-sites in similar situations outside the Goonumbla project area.

## 9. RECOMMENDATIONS

The sites within the project area are not directly threatened by the proposed development. project area activities will be restricted to the three mine locations with existing tracks being used for access. None of the creeks or the "gilgai" to the south will be disturbed in the course of gold and copper extraction. Consequently, no direct threat exists to the archaeological resources associated with these areas.

Given the minimal threat to the archaeological resources of the study area and the low scientific significance of the sites recorded, there can be no objection on archaeological grounds to the development and use of the area as a gold-copper mine .

Furthermore, no objections were raised to the development of the area as a mine by the representative of the local Aboriginal Land Council, although it was requested that the Council be provided with a copy of the report for educational purposes.

#### REFERENCE

10. Bowdler, S. 1983 Aboriginal Sites on the Crown-timber Lands of New South Wales. A Report to the Forestry Commission of New South Wales.

APPENDIX A

Archaeological Sites listed on the National Parks and Wildlife Service Site  
Register for the Upper Bogan Region Narromine 1:250,000 Map Sheet

35-2-0001	Bogan Rivers	Waterloo	Carved tree	
35-2-0002	Wallanbillan		Carved tree	
35-2-0003	Wendouree		Carved tree	Burial
35-5-0001	Curra	Curra Park	Open camp site	
35-5-0003	Curra		Carved tree	
35-5-0004	Gabondery		Open camp site	
35-5-0006	Tullamore		Carved tree	
35-5-0007	Back Creek		Carved tree	
35-5-0008	Aurora Park	Aboriginal Rubbing	Aboriginal Place	Axe grinding groove
35-5-0009	Aurora Park	Aurora Park Art Site	Aboriginal Place	Shelter C art
35-5-0010	Warge Rock		Aboriginal Place	Shelter C art
35-6-0001	Tralee	Coraki	Carved tree	
35-6-0002	Trewilga	Ten Mile Creek	Quarry	
35-6-0003	Pine Lagoon	Hazelbean	Carved tree	Scarred tree
35-6-0004	Bulgandramine Bridge		Carved tree	Burial
35-6-0005	Peak Hill		Quarry	
35-6-0006	Tomingley	Meroo	Carved tree	
35-6-0007	Bulgandramine	Bulgandramine Canoe	Scarred tree	
35-6-0008	Alectown	Newell Highway	Stone arrangement	
35-6-0009	Hollywood Station	Peak Hill	Scarred tree	
35-6-0010	Milo Mungery	Mungery	Carved tree	Burial
35-6-0011	Old Mungery		Carved tree	
35-6-0012	Tomingley Creek		Carved tree	
35-6-0013	Tomingley Creek		Carved tree	
35-6-0015	Mungerie		Scarred tree	
35-6-0016	Bulgandramine		Quarry	
35-6-0017	Bulgandramine		Carved tree	Quarry, ochre
35-6-0019	Mungerie Mission		Burial	
35-6-0020	Mungery		Carved tree	Burial
35-6-0021	Fiddlers Creek		Carved tree	
35-6-0022	Mingelo		Carved tree	

## APPENDIX B

### Description of Sites Recorded in the Survey

#### SITE 1

**Site type:** Open scatter of stone artefacts.

**Location:** On the east bank of the Bogan River, 150m north of a causeway on the Avondale - Trundle Road (Figure 3).

**Site Condition:** The site is exposed along vehicle tracks leading to a dam sunk into the channel of the Bogan River (Plate 1). The dam appears to have been sunk into part of the site and artefacts are eroding from the wall built during its construction. This, and vehicle traffic along the track have caused major disturbance to the site.

**Artefact types:** One polished edge ground axe was found at the site. The majority of artefacts were flakes and flaked pieces less than 5cm long. One had been retouched.

**Raw Materials:** The material used to make the edge ground axe was identified by the company geologist as tuff. The flakes and flaked pieces were made from black, white and yellow chert, silcrete, quartz and indurated mudstone (Plate 2).

**Density:** A total of 15 artefacts were exposed over an area of about 40m x 40m.

#### SITE 2

**Site type:** Open scatter of stone artefacts.

**Location:** The site was exposed in the roadside strip along the gravel road between Avondale and Trundle. The site is located 100m east of the causeway over the Bogan River in the 40m wide strip on the south side of the road.

**Site Condition:** Although remnants of the original vegetation have been relatively undisturbed in this area, the ground surface of the roadside strip has been severely affected by stock movement and vehicles involved in the construction of the road, fences and telegraph lines. Gravel



Plate 1 Site 1 looking west. Stone artefacts are exposed on the vehicle tracks in the foreground and on the wall of a dam built into the now dry channel of the Bogan River.

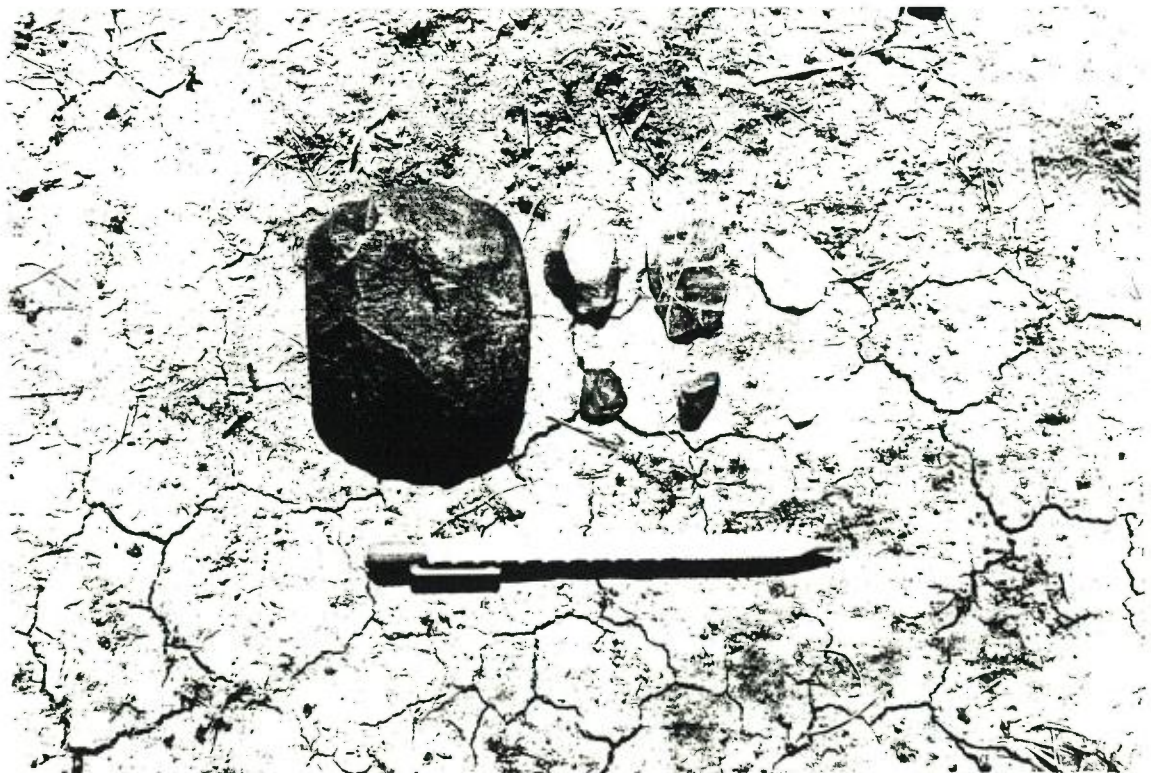


Plate 2 A selection of artefacts found disturbed at Site 1. The large piece is a worn or damaged polished edge-ground axe. The polish and some of the edge survives in the top right hand corner. The other artefacts are flakes < 5 cm long made on a variety of raw material including chert, indurated mudstone and quartz.

introduced for road-making and clusters of residual cobbles made archaeological interpretation difficult. Only 3 flakes could be confidently assigned as Aboriginal.

**Artefact types:** Unmodified flakes less than 3cm long.

**Raw materials:** Quartz.

**Density:** 3 artefacts were found in an area 40m x 100m.

### SITE 3

**Site type:** Open scatter of stone artefacts.

**Location:** On the east bank of the Bogan River, at its confluence with Goonumbla Creek.

**Site Condition:** This site has been exposed by grazing and the movement of stock to a dam sunk into the banks of the Bogan (Plate 3).

**Artefact types:** Mainly unretouched flakes and flaked pieces less than 5cm long, and one core (silcrete) with evidence of platform preparation was recorded.

**Raw Materials:** The dominant raw material was quartz, with lesser amounts of chert, jasper and silcrete.

**Density:** A total of 28 artefacts were recorded in an area of 100m x 100m. This site was the largest in area found during the survey.

### SITE 4

**Site type:** Open scatter of stone artefacts.

**Location:** On the west bank of the Bogan River at its confluence with Goonumbla Creek.

**Site condition:** The site has been disturbed by grazing and the traffic of vehicles.

**Artefact types:** One core with evidence of platform preparation (11cm x 5cm) and two unmodified flakes less than 2cm were recorded.

**Raw materials:** The core and one flake were made from silcrete. The other flake was made from yellow chert.

**Density:** Three artefacts were found in an area of 20m x 20m



Plate 3

The confluence of Goonumbla Creek and the Bogan River looking southwest. Site 3 has been exposed here by grazing and the movement of stock to the river and dam. Of those located, this site was the largest in area. The density of artefacts however, was low.

#### SITE 5

**Site type:** Open scatter of stone artefacts.

**Location:** West bank of the Bogan River, 200m downstream from its confluence with Goonumbla Creek.

**Site condition:** The site has been disturbed by grazing and the traffic of vehicles.

**Artefact types:** Unmodified flakes less than 4cm and one with retouch along one margin.

**Raw material:** The retouched flake was made from silcrete. Of the 15 artefacts recorded, 10 were quartz, 3 silcrete, one chert and one quartzite.

**Density:** The 15 artefacts were recorded in an area of 30m x 30m.

#### SITE 6

**Site type:** Open scatter of stone artefacts/scarred tree.

**Location:** On the north bank of Tenandra Creek, 200m west of the gravel road which crosses it.

**Site condition:** The site is exposed where stock have sought shade under a lone scarred tree. (Plate 4) Beyond this area visibility was generally poor, and it is possible that the stone artefact scatter is larger than the exposure reveals. The scarred tree is dying and in poor condition.

**Artefact types:** One large multi-platformed core was recorded with a flaked piece of the same material adjacent to it (Plate 5). The scarred tree is a species of box. The bottom of the scar occurs 65cm from the base of the tree and measures 180cm by 35cm (Plate 6).

**Raw materials:** The core and flake were made from silcrete.

**Density:** The two artefacts were located 20 m from the scarred tree.

#### SITE 7

**Site type:** Open scatter of stone artefacts.

**Location:** On the north bank of Tenandra Creek, 400m west of site 6 (Plate 7).



Plate 4 Site 6 on Tenandra Creek looking southwest. This site comprises one scarred tree and an open scatter of stone artefacts within a radius of 20m from the tree.

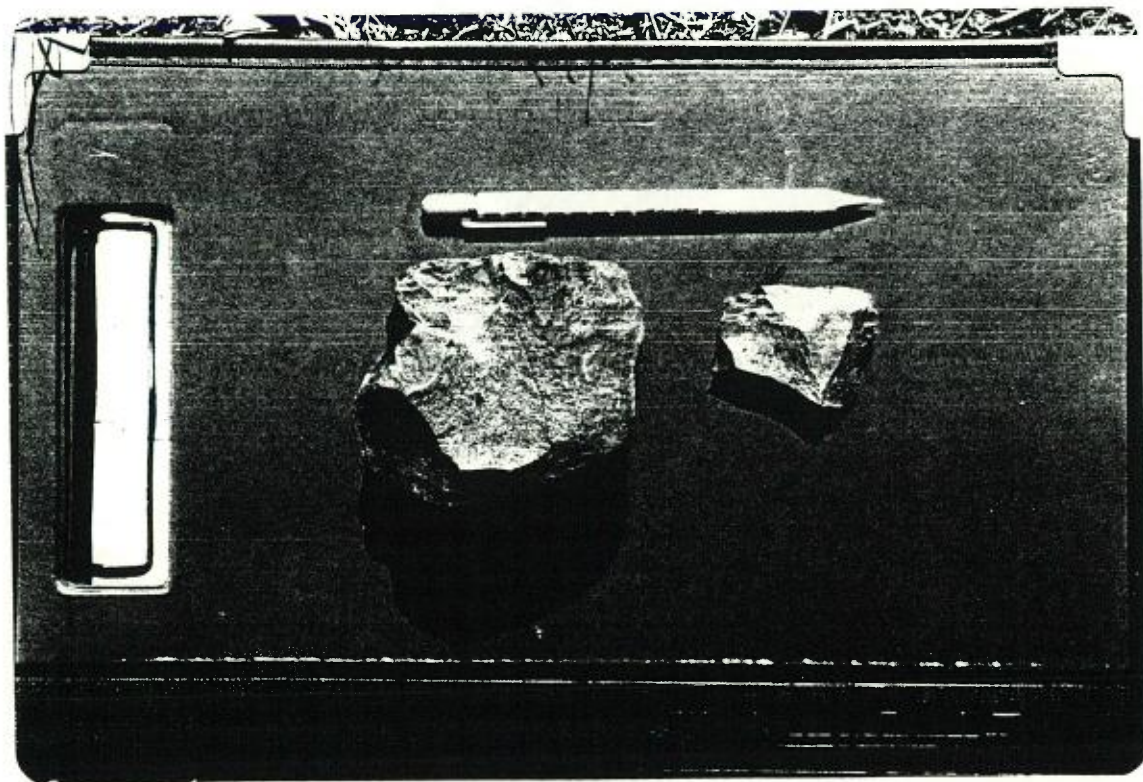


Plate 5 Two artefacts from Site 6. Both are of silcrete and may be conjoinable. The core has three striking platforms.

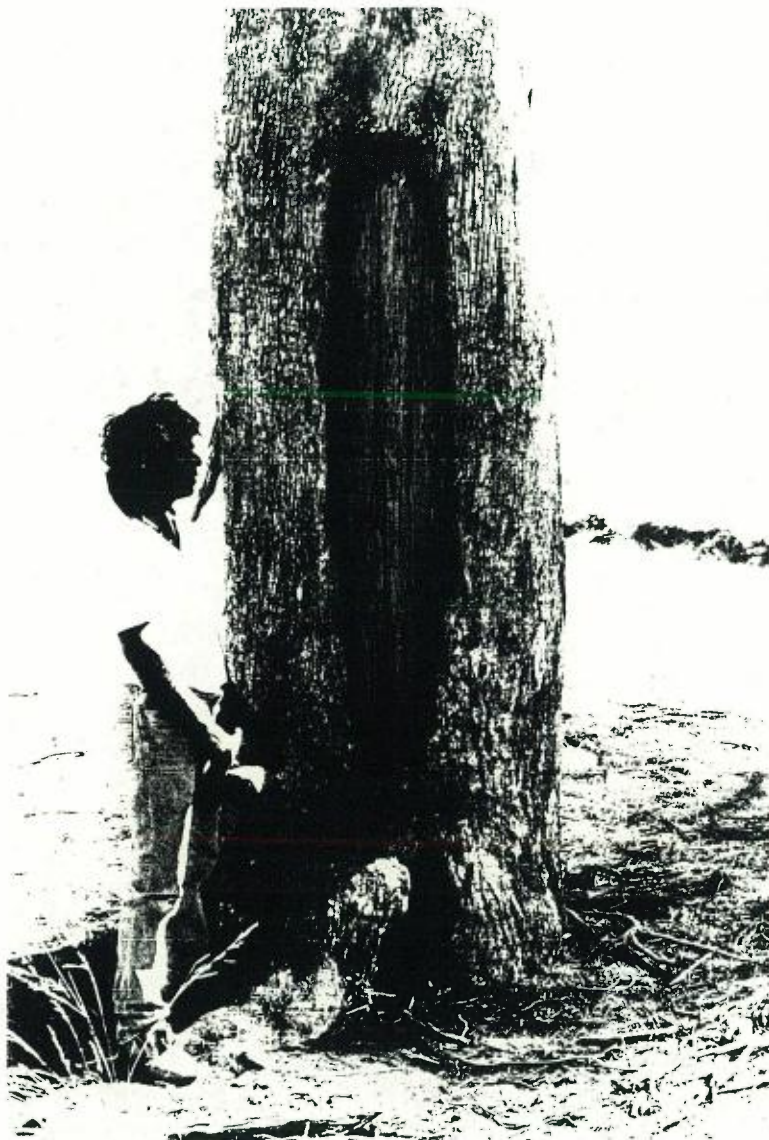


Plate 6

The symmetrical scar on the tree at Site 6 on Tenandra Creek.  
The tree is a box and the scar measures 180cm x 35cm.



Plate 7 Site 7 in Tenandra Creek, looking east towards Goonumbla Hill. Vehicles and stock have exposed a scatter of stone artefacts on the north bank. These occur in and around a Casuarina stand.

**Site condition:** Vehicles and stock have caused considerable soil erosion at this site. Artefacts were found in the vicinity of a Casuarina stand, where shade-seeking stock have disturbed the site.

**Artefact types:** Unmodified flakes and flaked pieces less than 4cm.

**Raw materials:** Chert, quartz, silcrete and indurated mudstone.

**Density:** A total of 8 artefacts were found in an area of 50m x 50m.

#### SITE 8

**Site type:** Open scatter of stone artefacts.

**Location:** On the north bank of Goonumbla Creek, 800m upstream from its confluence with the Bogan. The site is located in a ploughed field 50m from the creek.

**Site condition:** Ploughing has disturbed the site and brought some artefacts to the surface.

**Artefact types:** Unmodified flakes less than 3cm.

**Raw materials:** Chert, silcrete and quartz.

**Density:** A total of 8 artefacts were recorded in an area 50m x 30m.

#### SITE 9

**Site type:** Open scatter of stone artefacts.

**Location:** On the north bank of Goonumbla Creek, 200m upstream from Site 8 (Plate 8). The site is located in a ploughed field 50m from the creek.

**Site condition:** Considerable disturbance has been caused to the site by ploughing.

**Artefact types:** Unmodified flakes less than 3cm and a polished edge-ground axe similar to the one found at Site 1 (Plate 9).

**Raw materials:** All 9 flakes recorded were made from quartz. The axe was made from tuff.

**Density:** A total of 10 artefacts were recorded in an area of 30m x 30m.



Plate 8 Site 9 is located on the northern bank of Goonumbla Creek, 1km upstream from its confluence with the Bogan River. A second polished edge-ground axe was found on the ploughed surface where Ken Robinson is standing.

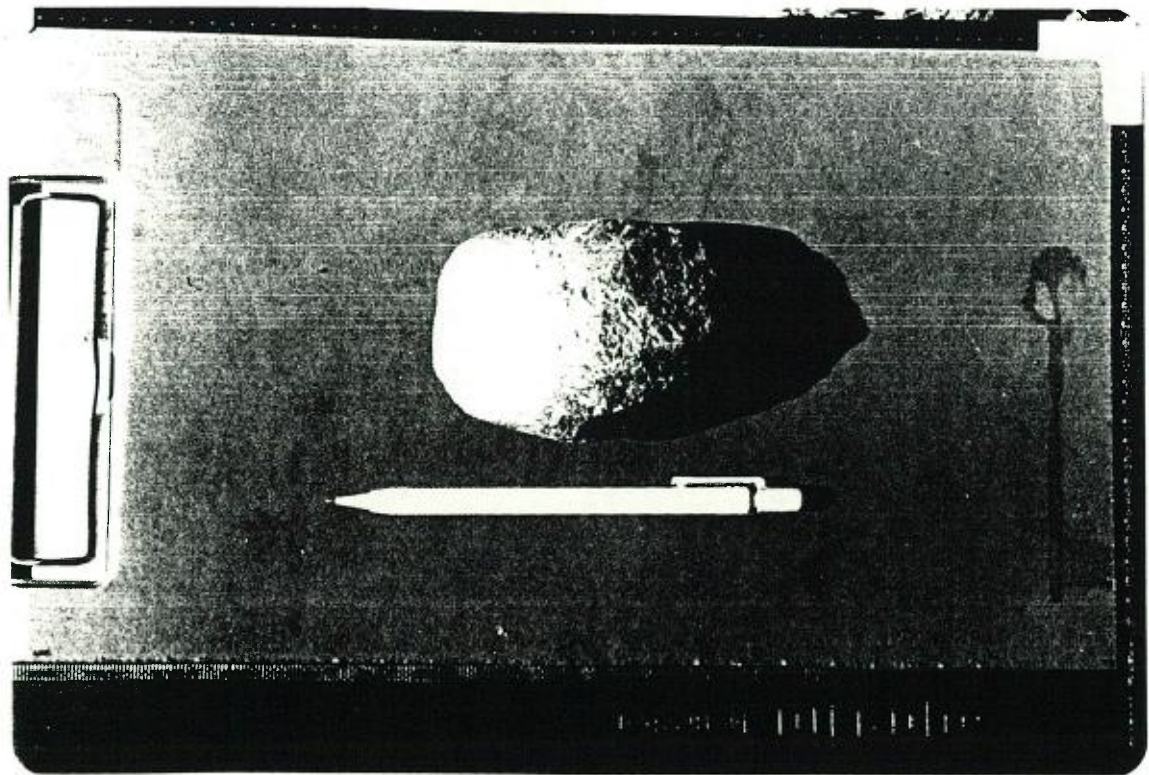


Plate 9 The polished edge-ground axe found at Site 9. Its dimensions are 9cm x 6cm x 3cm. The raw material is volcanic tuff.

## SITE 10

**Site type:** Open scatter of stone artefacts.

**Location:** On the north bank of Goonumbla Creek in the corner of a ploughed field. A track skirting the Limestone National Forest passes 20m from the site.

**Site condition:** Again, ploughing has caused considerable disturbance.

**Artefact types:** Of all artefacts brought to the surface at this site by ploughing at least 60% exhibited retouch and/or usewear (Plate 10). Also evident was a greater variety of artefact types. These included:

- 1 Indurated mudstone core tool (8cm x 5cm x 4cm) with retouch along one margin (Plate 10).
- 4 Chert flake tools less than 4cm with retouch and usewear along one margin.
- 1 Quartz core (3cm x 3cm x 3cm).
- 1 Quartz flake less than 3cm with retouch.
- 4 Unmodified quartz flakes and flaked pieces less than 4cm.

**Raw materials:** As above.

**Density:** A total of 12 artefacts were recorded in an area 50m x 50m.

## SITE 11

**Site type:** Open scatter of stone artefacts.

**Location:** In a ploughed field on the south bank of Goonumbla Creek, 300m downstream of where the track which skirts the Limestone National Forest crosses the creek.

**Site condition:** Exposed by ploughing.

**Artefact types:** Unmodified flakes and flaked pieces less than 4cm. One flaked piece with retouch and usewear was also recorded.

**Raw material:** Chert, silcrete, quartz and indurated mudstone.

**Density:** A total of 15 artefacts were recorded in an area 50m x 30m. Isolated quartz artefacts were recorded on average every 20m for 100m downstream from this site.

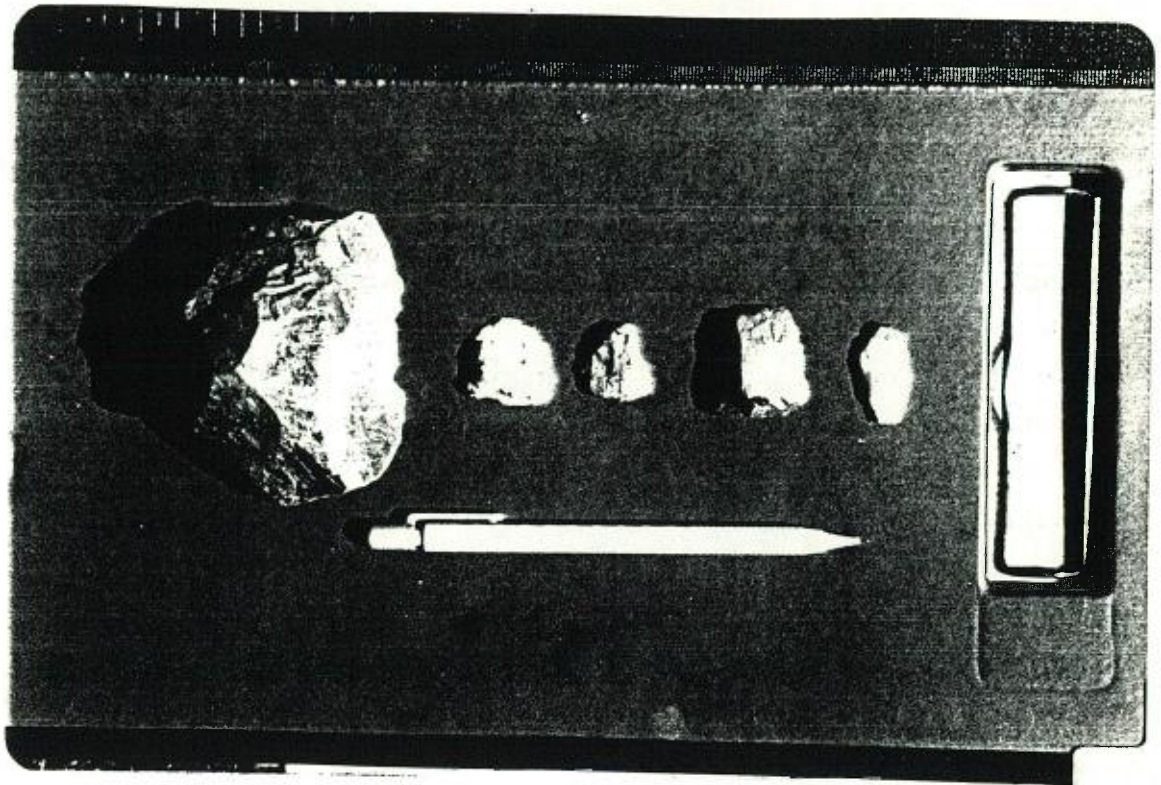


Plate 10 A selection of artefacts found ploughed to the surface at Site 10. in the middle reaches of Goonumbla Creek. All exhibit retouch and usewear along their right margins. The large unifacially flaked tool on the left is made of indurated mudstone.



Plate 11 Site 16 occurs on the northwestern margin of a "gilgai" at the southern end of the study area. Goonumbla Hill is in the background.

## SITE 12

**Site type:** Open scatter of stone artefacts.

**Location:** On the south bank of Goonumbla Creek, 1km from its confluence with the Bogan.

**Site condition:** Exposed by ploughing.

**Artefact types:** Unmodified flakes and a backed piece 3cm x 2cm.

**Raw material:** Quartz.

**Density:** Only three artefacts were recorded in an area of 30m x 30m.

## SITE 13

**Site type:** Open scatter of stone artefacts.

**Location:** On the east bank of the Bogan River, at its confluence with Tenandra Creek.

**Site condition:** Exposed by ploughing.

**Artefact types:** Unmodified flakes less than 4cm.

**Raw materials:** Chert, quartz and quartzite.

**Density:** A total of four artefacts were recorded in an area of 30m x 30m.

## SITE 14

**Site type:** Open scatter of stone artefacts.

**Location:** On the east bank of Tenandra Creek, 300m upstream from where a public road (running east-west) crosses the creek.

**Site condition:** Artefacts are eroding from the soil near a gate, where vehicle traffic has been heaviest.

**Artefact types:** Mostly unmodified flakes and flaked pieces less than 5cm. One elongate flake exhibited retouch and usewear.

**Raw materials:** Chert, indurated mudstone and quartz.

**Density:** A total of 12 artefacts were recorded within a radius of 30m from the gate.

**SITE 15**

**Site type:** Isolated find.

**Location:** On the west bank of Tenandra Creek, 1km upstream from Site 14.

**Site condition:** Exposed by ploughing.

**Artefact types:** One horse-hoof core (8cm x 6cm x 5cm).

**Raw materials:** Indurated mudstone.

**SITE 16**

**Site type:** Open scatter of stone artefacts.

**Location:** On the northwestern edge of a large "gilgai" on the Tenandra Plain. A dam has been sunk into the "gilgai" at this location (Plate 11).

**Site condition:** The site is exposed on the remains of a partially overgrown vehicle track.

**Artefact types:** Unmodified flakes and flaked pieces less than 5cm. One with retouch and/or usewear.

**Raw materials:** Chert, silcrete and quartz.

**Density:** A total of 10 artefacts were located in an area of 30m x 30m. The remaining area around the "gilgai" was covered by grass so it is possible that the site is more extensive than the exposure reveals.

**APPENDIX F**

**WASTE ROCK AND TAILINGS  
GEOCHEMISTRY TESTWORK**

Stuart Miller & Associates

GEOCHEMICAL ASSESSMENT OF OVERBURDEN, WASTE ROCK AND  
TAILINGS

GOONUMBLA PROJECT

Prepared by:

Stuart D Miller & Associates Pty Ltd  
August 1986

## TABLE OF CONTENTS

	Page
1.0 INTRODUCTION	3
2.0 OBJECTIVES	4
3.0 STUDY METHODS	5
3.1 Sample Collection and Preparation	5
3.2 Testing Procedures	7
4.0 RESULTS AND DISCUSSION	9
4.1 Overburden	9
4.2 Waste Rock	12
4.3 Tailings	12
5.0 IMPLICATIONS FOR WASTE MANAGEMENT AND REHABILITATION	14
5.1 Overburden	14
5.2 Waste Rock	14
5.3 Tailings	14
Attachments	
A: Total and Water Soluble Heavy Metals and Specific Ions: ICP-MS Analysis	
B: Criteria for Assessment of Results	

## LIST OF TABLES

1	Waste Rock and Low Grade Ore Sample Description	6
2	Description of Composite Overburden Samples	7
3	Saturation Extract Results- Major Parameters	10
4	Acid-Base Account for Waste Rock and Tailings	11
5	Sulphur Content of Ore	13

## 1.0 INTRODUCTION

This report presents the findings of investigations undertaken to evaluate the geochemical nature and leachate generating potential of overburden, waste rock and tailings from the proposed Goonumbla Project at Parkes in central west NSW.

The proposed mining operation involves the development of three porphyry copper-gold deposits. Each deposit will be mined by open pits methods and at the E26N deposit underground mining will also be carried out.

Samples of waste materials were collected from each deposit and examined to determine potential hazards associated with handling the wastes with respect to water pollution and rehabilitation. The report presents details of the sampling and testing programmes and the implications of the waste characteristics for waste management and rehabilitation. This data forms the basis for predicting short term and long term geochemical behaviour of the wastes at the disposal sites and provides the data base for sound engineering design of waste management operations.

## 2.0 OBJECTIVES

The objectives of the study were to investigate the geochemical nature of overburden, waste rock and tailings from the proposed Goonumbla Project near Parkes and to provide the geochemical data base for designing a sound waste disposal scheme. More specifically the objectives were to:

- \* review background data on the geology and the proposed mining operation;
- \* design a suitable testing programme for the geochemical evaluation of waste materials;
- \* direct the sampling and carry out the necessary test work;
- \* determine the geochemical characteristics and classify the potential toxicity of the waste types; and
- \* detail the implications of the waste characteristics for waste management and rehabilitation.

### 3.0 STUDY METHODS

#### 3.1 Sample Collection and Preparation

##### i) Overburden

Overburden consists of weathered unconsolidated material 10 to 60 metres thick covering the three ore deposits and appears to be residual in origin. A total of 34 individual depth samples of overburden were collected from 3 drill holes (one from each deposit). At E22, 9 samples were selected from the surface to a depth of 37 metres. At E27, 14 samples were selected from the surface to a depth of 54 metres and at E26, 11 samples were collected to a total depth of 55 metres.

All samples were air dried and passed through a 2mm sieve prior to chemical analysis.

##### ii) Waste Rock

Composite samples of waste rock and marginal ore were selected from each deposit for analysis. Four composite samples were collected from E22 and E26 and three composite samples from E27. At E27 and E26 the composite samples were selected from 8 drill holes and at E22 the samples were selected from 5 drill holes. At each drill hole subsamples were selected each 1 to 2 metres down the profile and pooled into the representative rock types. The rock types and sampling intervals are listed in Table 1.

All samples were crushed to pass a 4mm sieve prior to analysis.

##### iii) Tailings

Only one sample of bulk tailings was available for detailed chemical analysis and represents tailings from the open pit section of E26. Six additional tailings samples representing tailings from all three deposits were subsequently prepared for selected analyses.

TABLE 1: WASTE ROCK AND LOW GRADE ORE SAMPLE DESCRIPTION

Pit	Rock Type	Drill Hole	Sample Interval (metres)
E27	Marginal ore	E27D20	152-156
		E27D3	106-110
		E27D21	182-193
	Hardrock Waste	E27D3	80-106
		E27D12	35-57
		E27D13	61-100
		E27D19	38-88
		E27D20	47-63
	Oxide Ore	E27D29	24-57
		E27D23	30-57
E26	Marginal Sulphide Ore	E26D31	120-135
		E26D44	280-305
		E26D35	91-116
	Oxide Copper Ore	E26D86	37-65
		E26D30	65-80
		E26D26	65-79
	Hardrock Waste Gypsum Leached	E26D38	80-112
		E26D38	165-180
		E26D38	183-200
		E26D31	70-120
E26D35		115-180	
Hardrock Waste Carbonate Deposit	E26D38	200-220	
	E26D48	200-210	
	E26D35	215-240	
E22	Marginal Ore	E22D18	152-166
		E22D35	99-111
		E22D35	156-170
	Hardrock Waste Oxidised	E22D18	46-61
		E22D35	46-59
	Hardrock Waste Unoxidised	E22D18	61-127
		E22D35	59-99
		E22D35	170-179
	Oxide Ore	E22D3	42-59
		E22D19	59-64
E22D20		61-66	

### 3.2 Testing Procedures

This section describes the testing procedures undertaken on samples of overburden, waste rock and tailings. Sample preparation and leaching tests were carried out in Stuart D Miller & Associates Laboratory. Analytical determinations were performed by Analytical Services (WA) Pty Ltd, SGS Australia Pty Ltd and Warmans International.

#### i) Overburden

The pH and electrical conductivity was determined on a 1:2 (soil:water slurry) on all individual samples. From the results of these analyses and from the physical description and sample location of the individual samples, 11 composite samples were prepared for subsequent testing.

The description of the 11 composite samples are given in Table 2.

TABLE 2 DESCRIPTION OF COMPOSITE OVERBURDEN SAMPLES

Deposit	Sample Number	Depth Interval(m)
E27	C1	1.6-7.6
	C2	11-25
	C3	30-34.6
	C4	50-55
E22	C5	3-4.5
	C6	8.1-12.6
	C7	13.6-32.5
	C8	32.5-37.3
E26	C9	4.75-19
	C10	22.65-34.32
	C11	42.1-55.1

water saturation extracts were prepared on all composite samples. The extracts were analysed for pH, electrical conductivity, Ca, Mg, Na, K, SO<sub>4</sub>, Cl and HCO<sub>3</sub>. Composite samples C1, C2 and C9 were analysed by inductively coupled plasma-mass spectrometry (ICP-MS) to semiquantitatively determine the concentration of heavy metals and specific ions in the mass range 5 to 240.

Each sample was analysed for total sulphur and total levels of metals and specific ions were determined on samples C1, C2 and C9 by ICP-MS.

#### ii) Waste Rock

Saturation extracts were prepared on all waste rock samples and the extracts were analysed for pH, electrical conductivity, Ca, Mg, Na, K, SO<sub>4</sub>, Cl and HCO<sub>3</sub>. Extracts

from samples E22 Hardrock Waste(unoxidised), E26 Marginal Sulphide Ore and E27 Hardrock Waste were analysed by ICP-MS as described for overburden.

Total sulphur and the acid neutralising capacity were determined on each waste rock sample. Samples E22 Hardrock Waste(unoxidised), E26 Marginal Sulphide Ore and E27 Hardrock Waste were analysed by ICP-MS to determine total metals and specific ions.

Batch leaching tests were carried out on the following waste rock samples:

- E27 Marginal Ore
- E27 Hardrock Waste
- E27 Oxide Ore
- E26 Marginal Sulphide Ore
- E26 Hardrock Waste Gypsum Leached
- E26 Hardrock waste Carbonate Deposited
- E22 Hardrock Waste Oxidised
- E22 Hardrock Waste Unoxidised

The batch tests were carried out to examine the leaching mechanism under natural pH conditions. Samples of crushed waste rock were saturated with deionised water and humidified air was passed through the sample to ensure that maximum oxidising conditions were maintained. The leaching products were extracted at varying time intervals and have been analysed for pH and electrical conductivity. These tests have been running for 50 weeks and are continuing. The extracts have been retained for possible further analysis if necessary.

### iii) Tailings

A saturation extract was prepared on the bulk tailings sample and the extract analysed as for wasterock, including ICP-MS analysis.

The bulk tailings sample was also analysed for total sulphur, acid neutralising capacity and heavy metals and specific ions by ICP-MS.

The additional 6 tailings samples were analysed for total sulphur and sulphate sulphur

#### 4.0 RESULTS AND DISCUSSION

The analytical results for the major parameters in saturation extracts of overburden, waste rock and tailings are shown on Table 3. Table 42 shows the results of the sulphur determinations, acid neutralising capacity and the net acid producing potential for waste rock and tailings. Table 5 lists the sulphur determinations for the additional tailings samples. The results of the batch tests (to be included). The ICP-MS results for soluble and total heavy metals and specific ions are given in Attachment A. The criteria used for assessment of the results are given in Attachment B.

##### 4.1 Overburden

The overburden is low in total sulphur (0.03 to 0.18%S) with a high acid neutralising capacity and will not generate acid leachate.

Table 3 shows that the bulk of the overburden is highly saline and sodic ie high SAR (see attachment B for definition of SAR and assessment criteria). The pH indicates that the materials are neutral to slightly alkaline at E22 and E27 and slightly acid at E26.

Overburden salinity at E26 is high throughout the profile whereas at E22 and E27 only the upper 20 metres is highly saline. The sodic hazard at E26 is also greater than at E22 or E27. In addition, the sodic hazard decreases with depth at E22 and E27 but remains high throughout the profile at E26.

Water soluble constituents are dominated by Na and Cl although SO<sub>4</sub> is significant in some samples.

The results of multi-element analysis given in Attachment A, show that the overburden contains levels of F, B, As, Zn, Mo and Pb which are slightly greater than 'trigger levels' and Cu which is significantly greater than 'trigger levels'. Trigger levels are criteria used for assessing potential toxicity in waste materials and are presented in Attachment B. If trigger levels are exceeded then consideration must be given to further investigation of the potential toxicity and/or initiation of remedial action.

Investigations aimed at assessing the solubility of heavy metals and specific ions under the natural pH of the waste material showed that all elements (except Al) were below trigger levels. The level of Al was slightly elevated in the surface sample from E26 which had a natural pH of 4.9. The solubility of Al is directly related to the pH and does not imply excessively high levels of Al in the waste material. Controlling the pH will eliminate the potential Al toxicity in this material.

TABLE 3: WATER EXTRACTS (MAJOR PARAMETERS)

Sample	Sample Interval (m)			Solid- Liquid (AD)	pH	EC mS/cm	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	SO4 mg/l	Cl mg/l	HCO3 mg/l	SAR
	Upper	Lower	Mean											
E27 C1	1.6	7.6	4.6	0.583	7.7	7.17								
E27 C2	11.6	25	18.2	0.5	7.5	8.9	210	440	1800	3	890	3800	29	16.9
E27 C3	30.2	34.6	32.4	0.3	7.2	3.52	57	100	720	4	240	1500	22	13.6
E27 C4	54.5	54.5	54.5	0.277	7.7	0.57	2	4	120	2	92	120	60	11.3
E22 C5	3	4.5	3.5	0.609	6.5	5.4	97	260	1100	3	1200	1800	30	13.7
E22 C6	8.1	12.6	10.3	0.27	7.6	7.62	170	370	1500	3	1300	2700	60	15.4
E22 C7	13.6	32.5	23.0	0.47	7.4	3.4	130	150	550	3	400	1300	46	8.2
E22 C8	37.3	37.3	37.3	0.288	7.8	0.59	25	18	84	3	72	90	141	3.2
E26 C9	4.75	19	11.8	0.599	4.9	7.2	83	150	1600	10	750	2500	20	24.5
E26 C10	22.65	34.32	28.4	0.601	6.4	8.34	140	210	1900	18	890	3400	17	24.1
E26 C11	42.1	55.1	48.6	0.395	6.5	10.42	230	290	2400	19	1100	3900	30	25.3

Sample Description

E22 12	Marginal ore		0.211	7.7	0.93	13	4	190	12	240	130	110	11.8
E22 13	Hardrock Waste(Oxid)		0.211	7.8	0.98	18	17	180	9	180	150	147	7.4
E22 14	Hardrock Waste (unoxid)		0.218	8.1	0.83	13	6	160	13	190	77	115	9.2
E22 15	Oxidised Ore		0.218	7.9	0.75	26	23	120	10	100	90	204	4.3
E26 16	Hardrock waste -Gyp leached		0.228	8.3	5.05	65	48	1200	50	1000	1300		27.6
E26 17	Oxidised Copper Ore		0.243	7.2	3.44	14	20	820	19	370	1100	58	32.9
E26 18	Hardrock waste -Carb deposit		0.222	6.5	6.12	570	210	1100	140	3300	730	89	10.3
E26 19	Marginal Sulphide Ore		0.242	7.7	2.9	51	29	640	39	700	500	126	17.8
E27 20	Hardrock Waste		0.2	8	0.73	16	6	130	12	180	61	116	7.1
E27 21	Oxide Ore		0.2	8.1	0.67	21	14	110	7	75	100	131	4.7
E27 22	Marginal Ore		0.2	7.9	0.85	25	6	150	13	250	73	83	7.0
Tailings	E27 ore processing		0.38	7.3	3.45	530	45	500	94	2200	370		5.7

TABLE 4 ACID-BASE ACCOUNT FOR WASTE ROCK AND TAILINGS

Sample	S(total) %	ANC %CaCO3	NAPP %CaCO3
E22 12 Marginal ore	0.4	23.1	-21.8
E22 13 Hardrock Waste(Oxid)	0.27	12	-11.1
E22 14 Hardrock Waste (unoxid)	0.35	16.6	-15.5
E22 15 Oxidised Ore	0.11	14.3	-13.9
E26 16 Hardrock Waste-Gyp leached	0.58	11.8	-9.9
E26 17 Oxidised Copper Ore	0.15	8	-7.5
E26 18 Hardrock Waste-Carb deposit	1.21	23.3	-19.5
E26 19 Marginal Sulphide Ore	0.7	17.7	-15.5
E27 20 Hardrock waste	1.58	13.9	-8.9
E27 21 Oxide Ore	0.2	10.8	-10.1
E27 22 Marginal Ore	0.7	18.5	-16.3
Tailings From E27 ore processing	0.28	9.4	-8.5

## 4.2 Waste Rock

Table 4 shows that the waste rock at the three deposits is low in sulphur (0.11 to 1.58 %S) with a high acid neutralising capacity and a negative net acid producing capacity (NAPP). The NAPP ranges from -9 to -21 %CaCO<sub>3</sub> and indicates that the waste rock is non-acid forming and will not generate acid leachate. Batch leaching tests confirmed that the waste rock and ore samples tested are not acid forming. These batch tests are continuing and will provide longterm data on waste rock geochemistry (The results of the batch test will be included in the final draft).

Table 3 shows that waste rock at E22 and E27 has a low salinity whereas at E26 the waste rock salinity is moderate to high. The sodic potential is high at E26 and low at E22 and E27.

Multi-element analyses given in Attachment A show that the waste rock contains levels of F, Ba, Ag and Sr which are slightly greater than the trigger levels and Cu and Mo which are significantly greater than trigger levels. Solubility analysis and leachate testing showed that these elements were not mobile at the natural pH of the waste rock and that elevated levels are not expected to occur in leachates or in pore water. Slightly elevated Al levels were observed in hardrock waste samples from E22 and E27 however these are not expected to be a problem.

## 4.3 Tailings

The chemical composition of the tailings will be similar to the ore except that mineral processing to produce copper concentrate will have removed about 90% of the copper, together with associated elements.

The total sulphur and sulphate sulphur content of the ore from each deposit are given in Table 5. The results show that total sulphur in the ore from the underground and the open cut areas at E26N are similar. However, there is a higher level of sulphate in the underground ore which is due to an increase in the content of gypsum with increasing depth.

Ore from E27 and E22 has a lower total sulphur content than ore from E26N and a significantly lower level of sulphate sulphur.

The results given in Table 5 indicate that the total sulphur content of the ore is similar to the waste rock and is unlikely to be acid forming.

Only one sample of tailings was available for leachate analysis and this sample represents tailings from the open pit section of E26N. Table 4 shows that the tailings represented by the sample supplied are non acid

(0.28 %S and NAPP -8.5% CaCO<sub>3</sub>), non sodic and with a moderate salinity. The solubility testing showed that the leachates are dominated by Ca and SO<sub>4</sub> and that in the long term gypsum solubility will control the composition of leachates from the tailings.

Multi-element analysis of the tailings sample using ICP-MS semi-quantitative techniques identified Cu and Ba at concentrations greater than the 'trigger levels'. However, the solubility testing showed that heavy metals and specific ions will not be a problem in tailings leachate.

TABLE <sup>5</sup> ~~3~~: SULPHUR CONTENT OF ORE

Ore Type	Sulphate %S	Total %S
E26N Open Pit (volcanics)	0.18	0.81
E26N Open Pit (intrusives)	0.03	1.92
E26N Underground (volcanics)	0.83	1.28
E26N Underground (intrusives)	0.41	1.38
E27 Open Pit	0.01	0.38
E22 open Pit	0.004	0.41

## 5.0 IMPLICATIONS FOR WASTE MANAGEMENT AND REHABILITATION

This section describes the implications of the waste characteristics for mining, waste management and rehabilitation.

### 5.1 Overburden

The highly saline overburden will adversely affect revegetation and should not be placed within the root zone. The results indicate that all overburden (below the existing soil profile) is highly saline at E26 but only the upper 10 to 20 metres at E22 and E27 is saline. The material is high in clay and is sodic. This will result in low infiltration, high erosion and restricted plant growth when exposed on the surface or in the plant rooting zone.

The highly saline overburden will require selective handling to ensure that it is not exposed on the surface of dumps. As well as adversely affecting onsite rehabilitation, erosion and runoff from this material will adversely affect surrounding cropping land.

### 5.2 Waste Rock

The absence of toxic waste rock simplifies the waste disposal operation and imposes less restrictions on the design and construction of the final rehabilitated landform.

Further testing of waste rock will be necessary to confirm the preliminary findings and this will be carried out prior to preparation of the final design. In addition, ongoing monitoring will be carried out during mining to identify any important changes in material characteristics which may result in modification to the disposal strategy.

The available data indicates that waste rock will not require selective handling during the mining, waste disposal or rehabilitation operations. However the wasterock at E26 has a high salinity and is sodic. It will be necessary to ensure that sufficient topsoil is placed over these materials for successful rehabilitation.

### 5.3 Tailings

The tailings surface is expected to form a suitable substrate for rehabilitation. One metre of topsoil cover will form a good soil profile for plant growth and there will be no requirement for a specially designed cover, for example to prevent upward migration of contaminants or to reduce infiltration of water into the dump.

The composition of leachates from the tailings will be controlled by gypsum solubility, and leaching of heavy metals from the impoundment will be negligible.

Confirmatory testing of tailings samples will be carried out when additional material is available. However, the basic characteristics of the tailings suggests that no special precautions need to be undertaken to control leachates. Standard tailings dam design, good engineering practice and conventional rehabilitation measures will yield no contaminated runoff or leachate.

ATTACHMENT A

TOTAL AND WATER SOLUBLE HEAVY METALS AND SPECIFIC ION

ICP-MS ANALYSIS

\*\*\*\*\*

Sample C 2 OVERBURDEN (SATURATION EXTRACT)

Li = < 2 ppb	Be = < 1 ppb	B = 550 ppb	Na = 1800 ppm	Mg = 320 ppm	Al = 500 ppb
Si = 8.9 ppm	P = < 1000 ppb	S = 310 ppm	K = 3 ppm	Ca = 220 ppm	Sc = < 50 ppb
Ti = 100 ppb	V = < 50 ppb	Cr = 20 ppb	Mn = 10 ppb	Fe = 200 ppb	Ni = < 50 ppb
Co = 1.5 ppb	Cu = < 100 ppb	Zn = 100 ppb	Ga = < 0.5 ppb	Ge = < 50 ppb	As = < 200 ppb
Se = < 50 ppb	Br = < 10 ppm	Rb = 4.8 ppb	Sr = 5.6 ppm	Y = < 0.2 ppb	Zr = < 0.5 ppb
Nb = < 10 ppb	Mo = < 5 ppb	Ru = < 0.5 ppb	Rh = < .5 ppb	Pd = < 10 ppb	Ag = < 1 ppb
Cd = < 2 ppb	In = < 0.2 ppb	Sn = < 20 ppb	Sb = < 2 ppb	I = 800 ppb	Te = < 2 ppb
Cs = < 0.2 ppb	Ba = 160 ppb	La = 0.2 ppb	Ce = < 0.2 ppb	Pr = < 0.2 ppb	Nd = < 1 ppb
Sm = < 0.5 ppb	Eu = < 0.2 ppb	Gd = < 1 ppb	Tb = < 0.2 ppb	Dy = < 0.5 ppb	Ho = < 0.2 ppb
Er = 0.5 ppb	Tm = < 0.2 ppb	Yb = < 0.5 ppb	Lu = < 0.2 ppb	Hf = < 5 ppb	Ta = < 2 ppb
W = < 5 ppb	Re = < 0.5 ppb	Os = < 5 ppb	Ir = < 0.5 ppb	Pt = < 2 ppb	Au = < 1 ppb
Hg = 10 ppb	Tl = 1.0 ppb	Pb = < 50 ppb	Bi = < 0.5 ppb	Th = 0.5 ppb	U = < 0.5 ppb

Sample C 9 OVERBURDEN (SATURATION EXTRACT)

Li = 26 ppb	Be = 2 ppb	B = 1.4 ppm	Na = 1600 ppm	Mg = 130 ppb	Al = 2.1 ppm
Si = 28 ppm	P = < 1000 ppb	S = 280 ppm	K = 10 ppm	Ca = 84 ppm	Sc = < .50 ppb
Ti = < 50 ppb	V = < 50 ppb	Cr = 40 ppb	Mn = 410 ppb	Fe = 400 ppb	Ni = < 50 ppb
Co = 17 ppb	Cu = 400 ppb	Zn = 2.5 ppm	Ga = < 0.5 ppb	Ge = < 50 ppb	As = 600 ppb
Se = < 50 ppb	Br = < 10 ppm	Rb = 16 ppb	Sr = 2.0 ppm	Y = 5.6 ppb	Zr = < 0.5 ppb
Nb = < 10 ppb	Mo = < 5 ppb	Ru = < 0.5 ppb	Rh = < .5 ppb	Pd = < 10 ppb	Ag = < 1 ppb
Cd = 6 ppb	In = < 0.2 ppb	Sn = < 20 ppb	Sb = < 2 ppb	I = < 200 ppb	Te = < 2 ppb
Cs = < 0.2 ppb	Ba = 1.2 ppm	La = 4.4 ppb	Ce = 19 ppb	Pr = 1.8 ppb	Nd = 7 ppb
Sm = < 0.5 ppb	Eu = < 0.2 ppb	Gd = 2 ppb	Tb = < 0.2 ppb	Dy = 1.5 ppb	Ho = 0.2 ppb
Er = < 0.5 ppb	Tm = < 0.2 ppb	Yb = 1.0 ppb	Lu = < 0.2 ppb	Hf = < 5 ppb	Ta = < 2 ppb
W = < 5 ppb	Re = < 0.5 ppb	Os = < 5 ppb	Ir = 0.5 ppb	Pt = < 2 ppb	Au = < 1 ppb
Hg = 5 ppb	Tl = < 0.5 ppb	Pb = < 50 ppb	Bi = < 0.5 ppb	Th = < 0.5 ppb	U = 3.0 ppb

\*\*\*\*\*

Sample 14 E22 HARDROCK WASTE UNOXIDISED (SATURATION EXTRACT)

Li = 4 ppb	Be = < 1 ppb	B = 500 ppb	Na = 160 ppm	Mg = 5.5 ppm	Al = 2.8 ppm
Si = 8.2 ppm	P = < 1000 ppb	S = 70 ppm	K = 13 ppm	Ca = 13 ppm	Sc = < 50 ppb
Ti = < 50 ppb	V = < 50 ppb	Cr = < 10 ppb	Mn = 35 ppb	Fe = 600 ppb	Ni = < 50 ppb
Co = < 0.5 ppb	Cu = 100 ppb	Zn = < 100 ppb	Ga = < 0.5 ppb	Ge = < 50 ppb	As = 200 ppb
Se = < 50 ppb	Br = < 10 ppm	Rb = 13 ppb	Sr = 740 ppb	Y = < 0.2 ppb	Zr = < 0.5 ppb
Nb = < 10 ppb	Mo = 55 ppb	Ru = < 0.5 ppb	Rh = < .5 ppb	Pd = < 10 ppb	Ag = < 1 ppb
Cd = < 2 ppb	In = < 0.2 ppb	Sn = < 20 ppb	Sb = 4 ppb	I = < 200 ppb	Te = < 2 ppb
Cs = < 0.2 ppb	Ba = 190 ppb	La = < 0.2 ppb	Ce = 0.2 ppb	Pr = < 0.2 ppb	Nd = < 1 ppb
Sm = < 0.5 ppb	Eu = < 0.2 ppb	Gd = < 1 ppb	Tb = < 0.2 ppb	Dy = < 0.5 ppb	Ho = < 0.2 ppb
Er = < 0.5 ppb	Tm = < 0.2 ppb	Yb = < 0.5 ppb	Lu = < 0.2 ppb	Hf = < 5 ppb	Ta = < 2 ppb
W = < 5 ppb	Re = < 0.5 ppb	Os = < 5 ppb	Ir = < 0.5 ppb	Pt = < 2 ppb	Au = < 1 ppb
Hg = 5 ppb	Tl = < 0.5 ppb	Pb = < 50 ppb	Bi = < 0.5 ppb	Th = < 0.5 ppb	U = < 0.5 ppb

Sample 19 E26 MARGINAL SULPHIDE ORE (SATURATION EXTRACT)

Li = 14 ppb	Be = < 1 ppb	B = 350 ppb	Na = 640 ppm	Mg = 27 ppm	Al = < 500 ppb
Si = 3.1 ppm	P = < 1000 ppb	S = 280 ppm	K = 39 ppm	Ca = 50 ppm	Sc = < 50 ppb
Ti = < 50 ppb	V = < 50 ppb	Cr = 20 ppb	Mn = 210 ppb	Fe = 200 ppb	Ni = < 50 ppb
Co = 1.0 ppb	Cu = < 100 ppb	Zn = < 100 ppb	Ga = < 0.5 ppb	Ge = < 50 ppb	As = 400 ppb
Se = < 50 ppb	Br = < 10 ppm	Rb = 25 ppb	Sr = 6.0 ppm	Y = < 0.2 ppb	Zr = < 0.5 ppb
Nb = < 10 ppb	Mo = 1.0 ppm	Ru = < 0.5 ppb	Rh = < .5 ppb	Pd = < 10 ppb	Ag = < 1 ppb
Cd = 2 ppb	In = < 0.2 ppb	Sn = < 20 ppb	Sb = 4 ppb	I = < 200 ppb	Te = < 2 ppb
Cs = 0.2 ppb	Ba = 98 ppb	La = < 0.2 ppb	Ce = < 0.2 ppb	Pr = < 0.2 ppb	Nd = < 1 ppb
Sm = < 0.5 ppb	Eu = < 0.2 ppb	Gd = < 1 ppb	Tb = < 0.2 ppb	Dy = < 0.5 ppb	Ho = < 0.2 ppb
Er = < 0.5 ppb	Tm = < 0.2 ppb	Yb = < 0.5 ppb	Lu = < 0.2 ppb	Hf = < 5 ppb	Ta = < 2 ppb
W = < 5 ppb	Re = 2.0 ppb	Os = < 5 ppb	Ir = < 0.5 ppb	Pt = < 2 ppb	Au = < 1 ppb
Hg = < 5 ppb	Tl = < 0.5 ppb	Pb = < 50 ppb	Bi = < 0.5 ppb	Th = < 0.5 ppb	U = 2.5 ppb

\*\*\*\*\*

Sample 20	E27	HARDROCK WASTE (SATURATION EXTRACT)									
Li = 8 ppb	Be = < 1 ppb	B = 900 ppb	Na = 130 ppm	Mg = 5.9 ppm	Al = 1.5 ppm						
Si = 6.6 ppm	P = < 1000 ppb	S = 60 ppm	K = 12 ppm	Ca = 15 ppm	Sc = < 50 ppb						
Ti = 100 ppb	V = < 50 ppb	Cr = 30 ppb	Mn = 35 ppb	Fe = 7.5 ppm	Ni = < 50 ppb						
Co = < 0.5 ppb	Cu = < 100 ppb	Zn = < 100 ppb	Ga = < 0.5 ppb	Ge = < 50 ppb	As = 200 ppb						
Se = < 50 ppb	Br = < 10 ppm	Rb = 13 ppb	Sr = 860 ppb	Y = < 0.2 ppb	Zr = < 0.5 ppb						
Nb = < 10 ppb	Mo = 720 ppb	Ru = < 0.5 ppb	Rh = < .5 ppb	Pd = < 10 ppb	Ag = < 1 ppb						
Cd = < 2 ppb	In = < 0.2 ppb	Sn = < 20 ppb	Sb = 2 ppb	I = < 200 ppb	Te = 2 ppb						
Cs = < 0.2 ppb	Ba = 180 ppb	La = < 0.2 ppb	Ce = 0.2 ppb	Pr = < 0.2 ppb	Nd = < 1 ppb						
Sm = < 0.5 ppb	Eu = < 0.2 ppb	Gd = < 1 ppb	Tb = < 0.2 ppb	Dy = 0.5 ppb	Ho = < 0.2 ppb						
Er = < 0.5 ppb	Tm = < 0.2 ppb	Yb = < 0.5 ppb	Lu = < 0.2 ppb	Hf = < 5 ppb	Ta = < 2 ppb						
W = < 5 ppb	Re = 0.5 ppb	Os = < 5 ppb	Ir = < 0.5 ppb	Pt = < 2 ppb	Au = < 1 ppb						
Hg = < 5 ppb	Tl = < 0.5 ppb	Pb = < 50 ppb	Bi = < 0.5 ppb	Th = < 0.5 ppb	U = < 0.5 ppb						

Sample Soil (TAILINGS)

Li = 5 ppm	Be = 1.9 ppm	B = <100 ppb	Mg = 8500 ppm	Al = 4.1 %	Si = 18 %
P = <1000 ppm	S = < 2 %	K = ppb	Ca = 4000 ppm	Ti = 1000 ppm	V = 100 ppm
Cr = 11 ppm	Mn = 400 ppm	Fe = 1.2 %	Ni = 250 ppm	Co = < 5 ppm	Cu = 350 ppm
Zn = <100 ppm	Ga = 4.2 ppm	Ge = <100 ppb	As = <200 ppb	Se = < 50 ppm	Rb = 76 ppm
Sr = 480 ppm	Y = 12 ppm	Nb = < 50 ppm	Mo = 4 ppm	Pd = 1.5 ppm	Ag = < 50 ppm
Cd = < 5 ppm	In = <500 ppb	Sn = <100 ppb	Sb = <500 ppb	Te = < 5 ppm	Ce = <500 ppb
Ba = 670 ppm	La = 11 ppm	Ce = 23 ppm	Pr = 2.2 ppm	Nd = 10 ppm	Sm = < 1 ppm
Eu = 500 ppb	Gd = 2 ppm	Tb = 400 ppb	Dy = 2.8 ppm	Ho = 400 ppb	Er = 1.7 ppm
Tm = 400 ppb	Yb = 2.6 ppm	Lu = 200 ppb	Ta = < 50 ppm	W = < 20 ppm	Re = <500 ppb
Pt = < 2 ppm	Au = < 5 ppm	Tl = 1000 ppb	Pb = <100 ppm	Bi = < 1 ppm	Th = 3.1 ppm
U = 1.0 ppm					

Sample Water (TAILINGS)

Li = 9 ppb	Be = <0.5 ppb	B = 300 ppb	Mg = 37 ppm	Al = 480 ppb	Si = 5.2 ppm
P = 2.1 ppm	S = 810 ppm	Ca = 550 ppm	Sc = < 50 ppb	Ti = < 5 ppb	V = 5 ppb
Cr = < 50 ppb	Mn = 250 ppb	Fe = <200 ppb	Ni = < 50 ppb	Co = 7 ppb	Cu = 130 ppb
Zn = < 20 ppb	Ga = <0.5 ppb	Ge = <100 ppb	As = < 20 ppb	Se = < 50 ppb	Br = <500 ppb
Rb = 44 ppb	Sr = 6.9 ppm	Y = < 1 ppb	Zr = < 2 ppb	Nb = < 10 ppb	Mo = 140 ppb
Ru = <0.5 ppb	Rh = <0.1 ppb	Pd = < 2 ppb	Ag = < 20 ppb	Cd = < 1 ppb	In = <0.1 ppb
Sn = < 5 ppb	Sb = < 5 ppb	I = 82 ppb	Te = < 5 ppb	Cs = 0.4 ppb	Ba = 92 ppb
La = <0.5 ppb	Ce = 0.6 ppb	Pr = <0.2 ppb	Nd = <0.5 ppb	Sm = <0.5 ppb	Eu = <0.2 ppb
Gd = < 1 ppb	Tb = <0.1 ppb	Dy = <0.5 ppb	Ho = <0.1 ppb	Er = <0.5 ppb	Tm = 0.1 ppb
Yb = 0.5 ppb	Lu = <0.2 ppb	Hf = < 2 ppb	Ta = < 1 ppb	W = < 10 ppb	Re = 1.0 ppb
Os = < 10 ppb	Ir = <0.5 ppb	Pt = < 1 ppb	Au = < 1 ppb	Hg = 10 ppb	Tl = 0.4 ppb
Pb = < 20 ppb	Bi = <0.5 ppb	Th = <0.5 ppb	U = 2.4 ppb		

ATTACHMENT B

CRITERIA FOR ASSESSMENT OF RESULTS

### CRITERIA FOR ASSESSMENT OF RESULTS

Preliminary assessment of the geochemical nature of mine wastes involves the determination of the acid, salinity, heavy metal and specific ion hazards. Tests include the determination of total sulphur, acid neutralisation capacity, composition of water saturation extracts and determination of the level of soluble and total heavy metals and specific elements.

The results of these tests are assessed according to the suggested 'trigger levels' shown in table A1 and A4. Table A1 shows trigger levels for assessing the toxicity with respect to acid generation, salinity and sodicity. Table A4 is used for assessing specific element and heavy metal toxicity. If the trigger level is not exceeded the material is considered to be non-toxic and no further hazard assessment is necessary. If the trigger level is exceeded, consideration must be given to remedial action and initiation of more detailed investigations. Remedial action may involve selective placement and covering with suitable material, modification to the mine plan or water management, special surface management and reclamation techniques, chemical treatment eg. lime or gypsum or even selection of an alternative end use for the site.

Table A1  
Suggested 'Trigger Levels' for Overburden and Waste Rock

Parameter	Trigger Level
Net Acid Producing Potential (NAPP)	>0 %CaCO <sub>3</sub>
Total Sulfur	>0.5%
pH of saturation extract	<4.0
EC of saturation extract	> 2.0 mScm <sup>-1</sup>
Sodium Adsorption Ration (SAR)	>6.0

#### Acid Hazard

In table A1 the net acid producing potential (NAPP) is calculated from the total sulfur content and the inherent neutralising capacity and is defined as follows:

$$\text{NAPP (\%CaCO}_3\text{)} = \% \text{ S} \times 3.13 - \text{ANC (\% CaCO}_3\text{)} \quad (1)$$

where ANC = acid neutralising capacity.

In equation 1, 3.13 is a constant calculated from the pyrite oxidation reaction which shows that 1% sulphur (all as pyrite) yields an amount of sulphuric acid that requires 3.13 tonnes of calcium carbonate to neutralise 100 tonnes of material.

A negative NAPP means that there is excess acid neutralising capacity in the material. A positive result

indicates that the material is acid or may become acid in the long term.

Based on the results of more detailed investigations and from experience in dealing with acid forming wastes, five acid categories and management requirements are assessed as follows (the nil and low categories can generally be identified from the preliminary investigations) :

1. nil : overburden will not generate acid leachate or acid spoil and selective disposal is not required.
2. low : may be acid or have the potential to generate a very low concentration of acid. A light lime application will be necessary and the lime requirement must be determined.
3. medium: may be acid or have the potential to become acid in the long term producing a low concentration of acid and may require burial or treatment. Necessary to determine the reactivity of sulphides and the acid generating mechanism to determine the treatment options.
4. high: acid material that has the potential to generate a high concentration of acid following exposure and will continue to generate acid. Will require lime plus limestone treatment or burial. Necessary to determine the reactivity of sulphides and the acid generating mechanism to determine the treatment options.
5. very high : these are the most toxic units. They generate a high concentration of acid and have the potential to generate acid for a long time. It is uneconomic and ineffective in the long term to treat this spoil with lime. This material must be buried.

### Salinity Hazard

Salts in leachates can contaminate surface and ground water and salts in the spoil may prevent or restrict revegetation. The salinity ratings for using spoil as a plant growing medium (subsoil) are as follows:

Table A 2: Soil Salinity Rating

Salinity Hazard	Electrical Conductivity Saturation Extract (mS/cm)	Effect on Plants
Low	0-2	negligible
Medium	2-4	sensitive plants restricted
High	4-8	many plants restricted
Very High	8-16	only tolerant plants grow
Extreme	> 16	very few plants grow

Source: McNeely R N, Neimanis V P and Dwyer L 1979; and Richards (1954)

### Sodic Hazard

The SAR is a measure of the sodic nature (or sodium hazard) of spoil. A high proportion of sodium ions in spoil is of particular concern because of the adverse affect on clay stability and permeability. This can result in surface crusting, increased erosion, subsurface piping and collapse of spoil, and moisture stress on plants.

An estimate is made of the sodic nature of spoil by determinig the sodium adsorption ratio (SAR) on saturation extracts. The SAR is defined as :

$$\text{SAR} = \frac{(\text{Na} + 0.1\text{Mg})}{\sqrt{\{(\text{Ca} + \text{Mg})/2\}}}$$

where Na, Ca and Mg are in meq / l.

The criteria used for rating the sodic hazard are as follows:

Table A3 Soil Sodic Hazard

Sodic Hazard	SAR
low	0 - 6
medium	6 - 12
high	>12

Source: Bresler E, McNeal B L and Carter D L 1982

### Heavy Metal Hazard

Trigger levels for total and soluble heavy metals and specific ions are shown in tables A4 and A5. Table A4 shows the levels for the environmentally important elements and table A5 list the common levels for other elements in sedimentary rocks and soils. For major potential contaminants, the trigger levels for assessing the soil contamination with respect to human toxicology and redevelopment are presented. In addition, the concentration of metals in saturation extracts are compared with the range for soil solutions. In some cases it is necessary to evaluate the metal solubility with respect to standards for drinking water or aquatic organisms. This will depend upon site specific conditions and the potential or current use of surface or ground water resources.

The criteria presented in tables A4 and A5 are used for assessing the degree of soil contamination and toxicity to plants. To assess the impact of metals on receiving waters, dilution from uncontaminated runoff and attenuation by the environment must be considered.

Table A4

Trigger Levels for Environmentally Important Heavy Metals  
and Specific ions

Element	Rocks and Soils mg/kg	Soil Solution mg/l	Soil Contamination mg/kg
Li	200	30	
Be	5	0.5	15
B	100	1-5	
Al		0.1-30	
V	500	10	
Cr	100	0.5(VI)	200
Mn	1000	1-100	2000
Fe		20	
Ni	500	0.5-2	1000
Co	40	0.1-3	
Cu	100	0.5-8	200
Zn	100	60-400	
As	20	0.02-7.1	50
Se	2	1-2(IV)	5
Br	20	15-600	
Mo	5	0.5-2	
Cd	1	0.2-9	5
Sb	20		50
Ba	500	500	2000
Hg			3
Pb	30	3-20	750
Bi	0.5	25-30	
Th	15		
U	4		
F	1000	5	

Source : Bowen H J M (1979); Bresler E, McNeal B L and Carter D L (1982), Wilson and Stevens (1981) and Lindsay W L (1979).

Table A5

Common Levels of Other Heavy Metals and Specific Elements  
in Non-Mineralised Sedimentary Rocks and Soils

Element	Sedimentary Rocks mg/kg	Soils mg/kg
Sc	13	7
Ti	4600	5000
Ga	6	20
Ge	2	1
Rb	150	150
Sr	20-610	250
Y	23-41	40
Zr	20-220	400
Nb	0.05-18	10
Ru	≈ 0.001	
Rh	≈ 0.0002	
Pd	≈ 0.0008	
Ag	0.07-0.25	0.05
In	0.009-0.06	1
Sn	0.5-6	4
I	0.1-19	5
Te	≈ 0.005	
Cs	0.5-5.5	4
La	10-50	50
Ce	20-96	50
Pr	2.5-11	12
Nd	9-41	35
Sm	2-8.4	4.5
Eu	0.4-2	1
Gd	2.7-7.1	4
Tb	0.5-2	0.7
Dy	2.1-6.9	5
Ho	0.28-2	0.6
Er	1.7-4.9	2
Tm	0.2-1	0.6
Yb	1.6-4.4	3
Lu	0.16-0.8	0.4
Hf	0.3-3.9	6
Ta	0.05-2	2
W	0.56-1.9	1.5
Re	≈ 0.0002	
Os	≈ 0.00005	
Ir	≈ 0.00002	
Pt	0.0001	
Au	0.002-0.003	0.001
Tl	0.14-1.2	0.2

Source : Bowen H J M (1979)

**APPENDIX G**

**MINE AREA SOIL SURVEY**

Stuart Miller & Associates

MINE AREA SOIL SURVEY

Prepared by:

Stuart D Miller & Associates Pty Ltd

August 1986

## TABLE OF CONTENTS

	Page
1.0 INTRODUCTION	3
2.0 PREVIOUS STUDIES	4
3.0 STUDY METHODS	5
3.1 Field Programme	5
3.2 Physical Testing	5
3.3 Chemical Testing	5
4.0 RESULTS	6
4.1 Field Description and Soil Types	6
4.2 Analytical Results	7
5.0 SOIL MANAGEMENT AND RECOMMENDATIONS	9
6.0 STUDY TEAM	11
7.0 REFERENCES	12
ATTACHMENTS	13
A: Soil Analytical Results	
B: Field Site Description and Soil Profile Record Sheets	

## LIST OF FIGURES

Figure 1	Preliminary Soils Map	Attached
----------	-----------------------	----------

## 1.0 INTRODUCTION AND OBJECTIVES

As part of the preliminary environmental studies for the Goonumbla Project an investigation of the soils in the project area was undertaken. The aims of this investigation were to:

- broadly identify and classify soil types and assess their character;
- highlight any potential problems the soil may generate in relation to mining operations;
- evaluate the soil's potential as a source of topsoil material for future mine rehabilitation works; and
- outline any additional soil investigations necessary for developing sound soil management practice.

The Goonumbla site lies in central western NSW approximately 27 km north northwest of Parkes. Three copper ore bodies at the site are currently under investigation by the joint venture. Local land use comprises cereal crops such as wheat, barley, sorghum and oats mixed with grazing of beef cattle and sheep. Stocking rates average around 4 hectare per beef beast up to 1 hectare per beef beast on better areas.

Lying between the three ore bodies is the Limestone National Forest, a sparsely timbered area managed by the NSW Forestry Commission for the production of cypress pine. Rainfall in the area is low at around 500mm per annum and surface evaporation averages 2,400mm per annum. The area is drained by Goonumbla Creek, a tributary of the Bogan River.

The field work for this survey was undertaken in March 1986.

## 2.0 PREVIOUS STUDIES

Consultation with the NSW Soil Conservation Service (SCS) and the Department of Agriculture revealed the nearest significant soils investigation to the project area was a study undertaken by the SCS in the Bogan Gate area. The contents of this report, which included soils to the south west of Goonumbla, were discussed with the SCS at Parkes. No other surveys have been done in this area.

### 3.0 STUDY METHODS

#### 3.1 Field Programme

The study area is shown in Figure 1. The combination of the generally flat topography, lack of existing vertical soil exposures and difficulty in digging due to the very dry conditions, resulted in a survey of an opportunistic nature using a variety of soil observations. A total of 6 sites were described. Drill site sumps were available at sites S1 and S3, a soil core from the alluvial studies programme was used for site S2, portion of Golder's test pits were redug and used at site S5 and S6 and a hand auger was used at site S4. The soil profiles and site characteristics were described in the field and recorded on site description sheets which are presented in Attachment B of this Appendix.

Selected soil samples from test sites were taken for basic physical and chemical testing.

#### 3.2 Physical Testing

Field texture assessments were performed on the samples from all 6 sites. Selected samples were returned to the laboratory for the following analyses:

- field moisture content
- compaction characteristics
- bulk density
- saturated hydraulic conductivity
- Emerson crumb tests

#### 3.3 Chemical Testing

Field pH and electrical conductivities were determined on soil pastes for all soil horizons and layers identified. Selected samples were returned to the laboratory for the following determinations:

- pH ( $H_2O$  and  $CaCO_3$ ) in 1:2 w/w slurries
- electrical conductivity in 1:2 w/w slurries
- cation exchange capacity
- soluble and exchangeable cations
- organic matter content
- phosphorus (modified Olson method)
- DTPA extractable Cu, Mn, Fe and Zn
- carbonate content

207500E

210000E

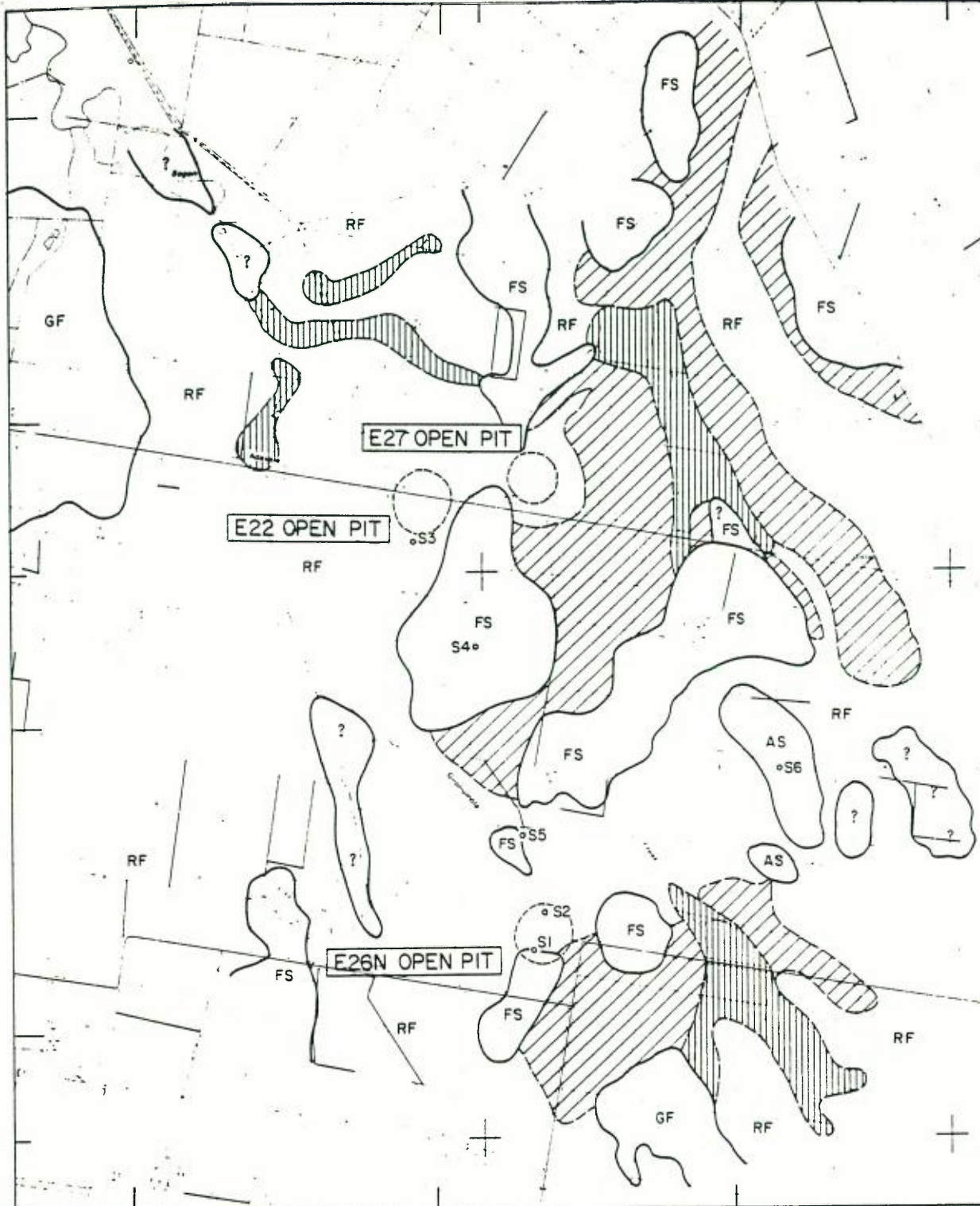
212500E

1360000

1357500

1355000

1352500



- FS FOREST SOILS
- RF RED BROWN EARTHS - RED FORM
- / / / / RED BROWN EARTHS - BROWN FORM
- | | | | RED BROWN EARTHS - GREY FORM
- AS ACID SOILS
- GF AREAS OF GILGAI FORMATION
- ? UNDETERMINED
- S1 SOIL SITES ( 6 SITES )

ISG 55/3 CO-ORDINATES SHOWN



**Natural Systems Research Pty. Ltd.**  
Environmental Consultants

**PRELIMINARY SOILS MAP**

**PARKES JOINT VENTURE**

**GOONUMBLA PROJECT**

Compiled by: GEOPEKO/SM

Date: JUNE 1986 A4 886

**Figure 1.**

## 4.0 RESULTS

### 4.1 Field Description and Soil Types

The low regional rainfall combined with the high surface evaporation is partly responsible for the local soils falling into the category known as mildly leached brown soils or otherwise showing little profile development. The following members of these two categories were identified in the study area:

- Red Brown Earths (sites S1, S2, S3, S4)
- Brown Clays (site S5)
- Non-Calcic Brown Soils (site S6)

Surface geology over the study area is comparatively uniform comprising deeply weathered trachyte. There is relatively little surface relief (the dominant landform being long slopes of less than 1%) and little microclimatic variation. Consequently the area is dominated by one great soil group, namely the Red Brown Earths.

The Red Brown Earths at Goonumbla are characterised by weakly structured topsoils (A horizons) over well developed and strongly pedal subsoils (B horizons). The A horizons are generally shallow, some 150-300mm deep with much deeper B horizons extending as much as 1700mm below the surface. The lighter textured A horizons are commonly clay loams overlying much heavier textured medium to heavy clay B horizons.

On drying, the surface soils are very hard setting and also are subject to periodic cracking. Evidence from the exploration drilling program suggest these cracks may be upto 20 metres deep. Internal drainage is generally good but slows as the cracks close on wetting.

pH trends from neutral at the surface to strongly alkaline at depth. Carbonate concretions are common often concentrating in the subsoils and manganese nodules are generally present. The subsoils become very sticky when wet.

A catenary relationship allied to topography exists in these Red Brown Earths and three forms, based on colour can be mapped as shown on Figure 1. A red form is present on the hill tops and upper slopes. The reddest of these have been left uncultivated and support tree growth. These have been mapped as Forest Soils. The red form grades into a red-brown form on the mid to lower slopes finishing with a grey form along the depressions and drainage lines.

The Brown Clays are part of a very broad group of soils whose common characteristic is the very high clay content. At site S5 this is reflected in light to light-medium clay A horizons overlying medium to heavy

clay B horizons over 600mm deep. The immediate surface soil lacks pedality having a massive appearance, but the subsequent horizons are very well developed and strongly pedal. Like the Red Brown Earths, pH ranges from neutral at the surface to strongly alkaline at depth. Abundant carbonate and manganese deposits occur through out the profile and the soils become very sticky when wet. On drying, wide deep cracks occur at the surface and extend to depth. Gilgai are often strongly developed on the Brown Clays.

The Non-Calcic Brown Soils are morphologically similar to the Red Brown Earths. The main differences being the lack of carbonates in the solum and hence the much more acid nature of these soils and they tend to be much thinner. The solum at site S6 was only 300mm deep. Although there are no free carbonates, manganese nodules are present. The soil is not as sticky as the Red Brown Earths or the Brown Clays and there is much less macropore development. These soils have been mapped as Acid Soils.

Two areas of gilgai formation lie in the south eastern and north western portion of the study area and are shown on Figure 1. Neither of these gilgai soils were closely examined during the present study, but further investigation is warranted if the project should lead to surface disturbance in either area.

Gilgai is a surface morphological feature of regular small scale undulations with alternate hummocks and hollows. Stace et.al. (1968) suggests the gilgai soils are 'best considered to be in a state of slow continuous movement in which soil from the deeper layers is brought to the surface on the mounds, and soil from the surface slips down to lower levels in the holes and cracks of the depressions.' Gilgai formation appears to be currently active as areas flattened by earthwoks and cultivation appear to reform in relatively short periods.

#### 4.2 Analytical Results

The soil horizons or layers from sites 1, 3 and 5 were analysed in the laboratory as outlined in Sections 3.1 and 3.2. The results of these tests are given in Attachment A.

The results show that the topsoils are slightly acid with a low salinity and the subsoils are strongly alkaline with a moderately high salinity. This trend was confirmed by the field pH and electrical conductivity measurements.

Soil titrations were carried out using  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  to determine the content of  $\text{CaCO}_3$ . The results show that in the subsoils the content of  $\text{CaCO}_3$  is approximately 0.1 to 0.2 % at each site.

The topsoil contains adequate organic matter but the lower horizons are low in organic matter. The cation exchange capacity is high in all horizons and reflects the generally high content of expandable clay in these soils.

In the topsoil the Mg to Ca ratio is satisfactory for plant growth, however in the subsoils Mg is dominant. Sodium increases with depth with a corresponding increase in the exchangeable sodium percentage.

The results of the Emerson stability tests show that the topsoils are Class 5 and 6 whereas the subsoils are Class 2, 3 or 4. The subsoils are likely to be suitable for earthworks, such as the tailings dam wall and, when compacted will form a good low permeability liner. The topsoils are not suitable for dam construction and should be stripped from these areas.

The topsoils have a low saturated permeability and the subsoils are very low. Wetting of the soil profile in the natural state is probably dependant on formation of cracks during drying which allow rapid entry of water following rainfall. Because of these low permeabilities in the subsoils, seepage from the tailings dam is expected to be small.

The phosphorus content of all soil horizons is adequate.

The level of DTPA extractable Fe is adequate in the topsoil but low in subsoils. Copper is adequate at sites 3 and 5 but very high in the subsoils at site 1. This site is down slope of the ore body and high copper levels would be expected.

Zinc and manganese are also high with manganese nodules occurring on the surface. The high levels of trace nutrients, particularly Cu and Zn in the subsoils is not a problem since these horizons are strongly alkaline and the elements are likely to be essentially insoluble.

## 5.0 SOIL MANAGEMENT AND RECOMMENDATIONS

The Preliminary soil reconnaissance survey, mapping and soil analysis programme indentified 3 main soil types;

- Red Brown Earths
- Brown Clays
- Non-Calcic Brown Soils.

The main soil type to be disturbed by the mining operation are the Red Brown Earths. These soils are characterised by weakly structured topsoils (A horizon) over well developed and strongly pedal subsoils (B horizon). The A horizons are generally shallow, 150 to 350mm with much deeper B horizons extending as much as 1700mm below the surface. The data indicate that these two soil horizons can be mixed and will form a good topsoiling material.

Frequently in the lower section of the B horizon and extending into the C horizon is a highly saline and dispersive clay material. Local farming experience with these clays when exposed on the surface indicates that they are unsuitable as a topsoil material. This horizon must be avoided when stripping and will define the limit of soil stripping.

A detailed field survey will be necessary to determine depth of stripping and the volumes of soil available in the areas disturbed. This will be undertaken at a later stage of project development, however the preliminary observations indicate that adequate good quality soil is available on site for rehabilitation purposes.

The A1 and B1 horizons generally show good structure, high cation exchange capacity, good organic matter content and adequate nutrient levels. In many areas where cultivation is active, the action of ploughing has destroyed much of the structure and mixing the plough layer with lower horizons is expected to improve the soils physical and chemical characteristics.

The soil should be handled at the moisture content where the soil shows a crumbly to labile consistence. The results indicate that this occurs at about 10 to 15% moisture in the soil. Stripping and stockpiling at this moisture content will greatly help to preserve the good physical properties of this soil.

Loaders and trucks will be suitable for soil handling and if necessary, the soil can be pushed into windrows by dozers to assist pickup. Truck built stockpiles should be designed to minimise compaction and should not be greater than 5 to 8 metres in height. A number of small stockpiles will be strategically placed around the perimeter of dumps and revegetated to minimise erosion.

In the natural soil, salt accumulation occurs at 500 to 1500mm depth in profiles away from drainage lines. This

is a function of soil type and climate but provides a guide to the topsoil depth required for rehabilitation. Based on the results and general field observations it is recommended that 300 to 500mm be applied to the slopes of waste dumps and 500 to 1000mm be applied to the surface where a high land capability is the final use objective.

The soils have a good moisture and nutrient holding capacity and will provide a good plant growing horizon for revegetation works. The soils insitu are moderately erosive due to long slope length and require some soil conservation works. The land is generally classified as Class 3 and soil conservation works are aimed at minimising sheet erosion. Gully erosion is generally not a problem in the Goonumbla area but on the steeper slopes of the waste dumps control and maintenance against gully erosion will be necessary.

Results indicate that soil compaction will not be a major problem during respreading of topsoil. Ripping on the contour after topsoil application will break up any small compacted zones and will also help to reduce erosion.

In summary, the soils on the Goonumbla site are of good quality and will provide an excellent substrate for successful revegetation. However, maintenance of soil structure is essential and is highly dependent on carrying out good soil management techniques as outlined in this section.

Highly calcareous subsoils will also provide an additional buffer to the migration of potential contaminants from the tailings disposal area.

## 6.0 STUDY TEAM

This investigation was carried out under the direction of Dr Stuart Miller, Stuart D Miller & Associates Pty Ltd. Mr Derry Thomas, Ryde School of Horticulture, was responsible for the field descriptions and soil classification and Mr Simon Leake, Sydney Environmental & Soil Laboratory Pty Ltd carried out the laboratory testing.

## 6.0 REFERENCES

Stace, H.C.T.; Hubble, G.D.; Brewew, R.; Northcote, K.H.; Sleeman, J.R.; Mulchany, M.J.; and Hallsworth, E.G. (1968). A Handbook of Australian Soils. Rellim Technical Publications South Australia.

ATTACHMENT A  
SOIL ANALYTICAL RESULTS

## SAMPLE DESCRIPTION

The sample numbers used in the attached laboratory reports are defined as follows:

SITE	SAMPLE	DEPTH (mm)
1	1	0-200
	2	200-400
	3	400-800
	4	800-2750
3	PL(plough layer)	0-100
	1	100-300
	2	300-750
	3	750-1500
5	1	0-100
	2	100-300
	3	300-450
	4	450-600

# SYDNEY ENVIRONMENTAL & SOIL LABORATORY PTY. LTD.

*Simon Leake* B.Sc., Ag. (Hons I). Syd.  
Managing Director

10 Elizabeth Street,  
Paddington, 2021  
Phone: (02) 33 0528  
P.O. BOX 135,  
PADDINGTON, 2021

## RESULT SHEET

Sample and Name: S Miller, Site 1. Parkes.

TEST	Sample	1	2	3	4
pH in H <sub>2</sub> O		5.74	6.66	8.23	8.78
pH in CaCl <sub>2</sub>		5.13	6.40	8.00	8.25
E. C. mmhos/cm	1:2w/w	0.77	0.92	0.89	7.76
CEC meq%		7.0	17.4	21.0	18.6
Organic matter %		3.7	0.5	0.2	0.1
Texture		Lfs	LC	M-HC	CL (gravel)
Solubles Na		0.3	0.88	1.08	1.06
meq%	K	0.250	0.030	0.01	0.012
	Ca	0.22	0.12	0.08	0.02
	Mg	0.00	0.32	0.20	0.12
Totals	Na	0.35	1.85	2.90	3.70
	K	1.36	0.41	0.27	0.54
	Ca	4.5	5.1	5.6	3.7
	Mg	2.2	10.7	12.5	11.3
Nutrient ppm					
	P	95	105	82	65
Field MC g/g		0.039	0.179	0.182	0.100
Mn ppm		37.2	1.0	0.7	0.9
Fe		8.0	0.4	0	0
Zn		15.4	17.0	1.3	1.0
Cu		6	30	20	5

Additional Emerson Stabilities;

Tests:	Weak slaking	Rapid slaking	"	"
	No Disp	swelling	sl disp	sl disp
	Class 5	Class 4	Class 2	Class 2

# SYDNEY ENVIRONMENTAL & SOIL LABORATORY PTY. LTD.

Simon Leake B.Sc., Ag. (Hons I), Syd.  
Managing Director

10 Elizabeth Street,  
Paddington, 2021  
Phone: (02) 33 0528  
P.O. BOX 135,  
PADDINGTON, 2021

## RESULT SHEET

Sample and Name: S. Miller Site 3 Parkes

TEST Sample	1	PL	2	3
pH in H <sub>2</sub> O	6.43	6.45	7.96	7.90
pH in CaCl <sub>2</sub>	5.67	5.82	7.66	7.67
E. C. mmhos/cm 1:2 w/w	0.18	0.16	1.74	3.31
CEC meq%	16.4	15.5	24.2	24.2
Organic matter %	1.9	0.9	0.6	0.2
Texture	CL	MC	L-MC	CL
Solubles Na meq%	0.14	0.06	2.16	3.88
K	0.062	0.060	0.008	0.016
Ca	0.06	0.06	0.292	0.764
Mg	0.112	0.092	0.116	0.280
Totals Na	0.70	0.25	4.70	6.05
K	0.485	0.700	0.135	0.165
Ca	7.3	7.6	7.6	8.1
Mg	8.1	6.7	13.9	15.0
Nutrient ppm				
P ppm	94	107	95	146
Field MC g/g	0.112	0.232	0.21	0.05
K <sub>sat</sub> cm/s	3.2EXP-4	4.3EXP-5	2.3EXP-4	1.1EXP-4 *
Bulk Density g/cc	1.70	1.73	1.44	1.44 *
Mn ppm	10.2	11.1	1.1	3.0
Fe	0.52	0.35	0.00	0.05
Zn	11.1	12.3	1.6	5.5
Cu	0.7	0.3	0.3	0.7

Additional Tests: \* Note, K<sub>sat</sub> done with disturbed samples < 2mm  
 Density done with wax block method on large aggregates.  
 Rapid SL                      Weak SL    RAPID SL                      RAPID SL  
 Class                      5                      5                      3                      4

# SYDNEY ENVIRONMENTAL & SOIL LABORATORY PTY. LTD.

Simon Leake B.Sc., Ag. (Hons I), Syd.  
Managing Director

10 Elizabeth Street,  
Paddington, 2021  
Phone: (02) 33 0528  
P.O. BOX 135,  
PADDINGTON, 2021

## RESULT SHEET

Sample and Name: S. Miller Site 5, Parkes

TEST	Sample	1	2	3	4
pH in H <sub>2</sub> O		5.68	8.09	8.34	8.34
pH in CaCl <sub>2</sub>		5.44	7.70	8.10	8.03
E. C. mmhos/cm 1:2 w/w		1.57	1.17	1.64	2.70
CEC meq%		19.2	23.5	23.7	23.6
Organic Matter %		3.5	1.6	0.5	0.4
Texture		CL	CL	MC	HC
Solubles Na meq%		1.78	1.14	2.10	3.98
K		0.040	0.002	0.0	0.002
Ca		0.244	0.18	0.16	0.20
Mg		0.32	0.17	0.19	0.31
Totals Na		3.50	3.40	5.85	9.25
K		0.56	0.14	0.07	0.08
Ca		8.2	10.8	8.2	6.7
Mg		8.4	10.5	10.9	11.0
Nutrient ppm					
P		87	97	87	85
Field MC g/g		0.073	0.145	0.18	0.20
K <sub>sat</sub> cm/s		4.9EXP-3	9.1EXP-5	3.3EXP-4	Too low *
Bulk Density g/g		1.15	1.37	1.31	1.26 *
Mn ppm		37.6	0.80	0.0	0.0
Fe		2.45	0	0	0
Zn		13.0	0.10	0	0
Cu		0.22	0.33	0.29	0.60

Additional Tests: \* Note, K<sub>sat</sub> and Density done on disturbed samples.  
                                     Weak slaking      slaking      Both rapid slaking  
   No disp              sl disp              no disp

Class              6 or 8                      5 or 6              4                      4

ATTACHMENT B

FIELD SITE DESCRIPTION AND SOIL PROFILE RECORD SHEETS

SITE S1 cont.

### SOIL PROFILE RECORD 'A'

slakes slightly  
slakes strongly  
slakes

Layer No.	Horizon	Lower Average Depth (m)	Dominant Colour (Munsell Code)		Mottle							pH	
			Moist	Dry	Primary			Secondary					
					Abund.	Size	Contr.	Abund.	Size	Contr.	Soil Water Sat.		
1	A1	0:15	5.0YR 3/4										8.5
2	B1	0:52	2.5YR 3/6										7.5
3	B2	0:75	5.0YR 3/8										8.5
4	C1	2:10	2.5YR 4/6										8.5
5													
6													

Record Type  
# # # #

### SOIL PROFILE RECORD 'B'

**FIELD TEXTURE**

**SAND FRACTION**

MA#1	1	2	3	4	5	6	Fine
MA#2							Coarse

**GRADE**

MB#1	1	2	3	4	5	6	Sand
MB#2							Loamy Sand
MB#3							Clayey Sand
MB#4							Sandy Loam
MC#1							Fine Sandy Loam
MC#2							Light Sandy Clay Loam
MC#3							Loam, Fine Sandy
MD#1							Silt Loam
MD#2							Sandy Clay Loam
ME#1							Clay Loam
ME#2							Silty Clay Loam
ME#3							Fine Sandy Clay
ME#4							Sandy Clay Loam
MF#1							Silty Clay
MF#2							Light Clay
MF#3							Light Medium Clay
MF#4							Medium Clay
MG#1							Heavy Clay

**COARSE FRAGMENTS**

**ABUNDANCE**

NA#1	1	2	3	4	5	6	None
NA#2							0-2%
NA#3							2-10%
NA#4							10-20%
NA#5							25-50%
NA#6							50-90%
NA#7							>90%

**SHAPE**

NB#1	1	2	3	4	5	6	Rounded
NB#2							Subrounded
NB#3							Subangular
NB#4							Angular

**DISTRIBUTION**

NC#1	1	2	3	4	5	6	Reoriented
NC#2							Undisturbed
NC#3							Stratified
NC#4							Dispersed

**SIZE**

ND#1	1	2	3	4	5	6	2-6 mm
ND#2							6-20mm
ND#3							20-60 mm
ND#4							60-200mm
ND#5							200-600mm
ND#6							>600mm

**LITHOLOGY**

NE#1	1	2	3	4	5	6	Quartz
NE#2							Igneous
NE#3							Sedimentary
NE#4							Metamorphic
NE#5							Same As Parent Material
NE#6							Not Identified

**STRUCTURE GRADE**

**Primary**

PA#1	1	2	3	4	5	6	Apedal Single
PA#2							Apedal Massive
PA#3							Weak Pedality
PA#4							Moderate Pedality
PA#5							Strong Pedality

**Secondary**

PB#1	1	2	3	4	5	6	Platy
PB#2							Prismatic
PB#3							Columnar
PB#4							Angular Blocky
PB#5							Subangular Blocky

**PED SIZE**

**Primary**

PC#1	1	2	3	4	5	6	<2mm
PC#2							2-5mm
PC#3							5-10mm
PC#4							10-20mm
PC#5							20-50mm
PC#6							50-100mm
PC#7							100-200mm
PC#8							200-500mm
PC#9							>500mm

**Secondary**

PD#1	1	2	3	4	5	6	<2mm
PD#2							2-5mm
PD#3							5-10mm
PD#4							10-20mm
PD#5							20-50mm
PD#6							50-100mm
PD#7							100-200mm
PD#8							200-500mm
PD#9							>500mm

**PED TYPE**

**Primary**

PE#1	1	2	3	4	5	6	Platy
PE#2							Prismatic
PE#3							Columnar
PE#4							Angular Blocky
PE#5							Subangular Blocky
PE#6							Polyhedral
PE#7							Lenticular
PE#8							Granular
PE#9							Cxst.

**Secondary**

PF#1	1	2	3	4	5	6	Platy
PF#2							Prismatic
PF#3							Columnar
PF#4							Angular Blocky
PF#5							Subangular Blocky
PF#6							Polyhedral
PF#7							Lenticular
PF#8							Granular
PF#9							Cxst.

**FABRIC**

QA#1	1	2	3	4	5	6	Earthy
QA#2							Sandy
QA#3							Smooth Ped
QA#4							Rough Ped

**CUTANS**

RA#1	1	2	3	4	5	6	None
RA#2							Few (<10%)
RA#3							Common (10-50%)
RA#4							Many (>50%)

**VOIDS**

**PORES**

SA#1	1	2	3	4	5	6	Macropores
SA#2							No macropores

**CRACK WIDTH**

SB#1	1	2	3	4	5	6	<5mm
SB#2							5-10mm
SB#3							10-20mm
SB#4							20-50mm
SB#5							>50mm

**CONSISTENCE**

**STRENGTH**

TA#1	1	2	3	4	5	6	Loose
TA#2							Very Weak
TA#3							Moderately Weak
TA#4							Moderately Firm
TA#5							Very Firm
TA#6							Moderately Strong
TA#7							Very Strong
TA#8							Rigid

**PLASTICITY TYPE**

TB#1	1	2	3	4	5	6	Superplastic
TB#2							Normal Plastic
TB#3							Subplastic
TB#4							Strongly Plastic

**STICKINESS**

TC#1	1	2	3	4	5	6	Non Sticky
TC#2							Slightly Sticky
TC#3							Moderately Sticky
TC#4							Very Sticky (extremely sticky)

**PANS**

**CEMENTATION**

UA#1	1	2	3	4	5	6	Uncemented
UA#2							Weakly Cemented
UA#3							Moderately Cemented
UA#4							Strongly Cemented
UA#5							Very Strongly Cemented

**TYPE**

UB#1	1	2	3	4	5	6	No Pans
UB#2							Calcicrete
UB#3							Silcrete
UB#4							Iron Pan
UB#5							Sesquioxide Pan
UB#6							Orstein
UB#7							Coffee Rock
UB#8							Other

**CONTINUITY**

UC#1	1	2	3	4	5	6	Continuous
UC#2							Discontinuous
UC#3							Broken

**SEGREGATIONS**

**ABUNDANCE**

VA#1	1	2	3	4	5	6	0
VA#2							<2%
VA#3							2-10%
VA#4							10-20%
VA#5							20-50%
VA#6							>50%

**NATURE**

VB#1	1	2	3	4	5	6	Calcareous
VB#2							Gypsiferous
VB#3							Ferruginous
VB#4							Manganiferous
VB#5							Organic
VB#6							Other

**FORM**

VC#1	1	2	3	4	5	6	Nodular
VC#2							Crystals
VC#3							Soft Segregations

**SIZE**

VD#1	1	2	3	4	5	6	<2mm
VD#2							2-6mm
VD#3							6-20mm
VD#4							20-60mm
VD#5							>60mm

**ROOTS**

WA#1	1	2	3	4	5	6	None
WA#2							Few
WA#3							Common
WA#4							Many
WA#5							Abundant

**BOUNDARY DISTINCTNESS**

XA#1	1	2	3	4	5	6	Sharp (<5mm)
XA#2							Abrupt (5-20mm)
XA#3							Clear (20-50mm)
XA#4							Gradual (50-100mm)
XA#5							Diffuse (>100mm)

**SHAPE**

XB#1	1	2	3	4	5	6	Smooth
XB#2							Wavy
XB#3							Irregular
XB#4							Broken

Figure 19 Example of cross-out site description sheet — reverse

# CROSS-OUT SITE DESCRIPTION SHEET HEADER RECORD

Record Type # # # 1		Safety Code GEO		Site 51		Great Soil Group Code K8E D C 2:13		Principal Profile Form		Soil or Land Class	
Description PHOR		Photo		Reference		Date					
Firm Number		Run No.		Frame No.		East		North		Day Month Year	
7		1718		94		67		08		0386	
Map Sheet Number		Map Scale 1		Map Zone		Eastings / Latitude		Northings / Longitude			
8.532-11-111		50000		SSM69		063.54400					
Slope Value		Elevation (m)		Aspect		Depth of Regolith (m)		Depth of Standing Water		Rainfall (mm)	
< 1%		282		---		0		2.90		552	

## LANDFORM, VEGETATION, LANDSURFACE, SUBSTRATE MATERIAL RECORD

Record Type  
# # # 2

### LANDFORM

#### LANDFORM ELEMENT MORPHOLOGICAL TYPE

- AA#1  Crest
- AA#2  Upper Slope
- AA#3  Mid-Slope
- AA#4  Lower Slope
- AA#5  Simple Slope
- AA#6  Flat
- AA#7  Open Depression
- AA#8  Closed Depression
- AA#9  Hitlock
- AA#10  Ridge

### VEGETATION

#### TYPE OF FOREST

- BA#1  Non-Rainforest
- BA#2  Rainforest

#### STRUCTURAL FORMATION CLASS

BC#1	<input type="checkbox"/>	Tree
BC#2	<input type="checkbox"/>	Tree Mallee
BC#3	<input type="checkbox"/>	Shrub
BC#4	<input type="checkbox"/>	Melaleuc Shrub
BC#5	<input type="checkbox"/>	Heath Shrub
BC#6	<input type="checkbox"/>	Chenopod Shrub
BC#7	<input type="checkbox"/>	Hummock Grass
BC#8	<input type="checkbox"/>	Tussock Grass
BC#9	<input type="checkbox"/>	Sedge
BC#10	<input type="checkbox"/>	Rush

#### UPPER STRATUM HEIGHT CLASS

BD#1	> 35.0m
BD#2	20.01 - 35m
BD#3	12.01 - 20m
BD#4	6.01 - 12m
BD#5	3.01 - 6m
BD#6	1.01 - 3m
BD#7	0.51 - 1m
BD#8	0.26 - 0.5m
BD#9	< 0.25m

#### DOMINANT SPECIES

BE#1	<input type="checkbox"/>
BE#2	<input type="checkbox"/>
BE#3	<input type="checkbox"/>

### LANDSURFACE

#### CONDITION OF SURFACE SOIL

- CA#1  Periodic Cracking
- CA#2  Soil Mulching
- CA#3  Loose Soil
- CA#4  Firm
- CA#5  Hard Setting
- CA#6  Surface Crust
- CA#7  Recently Cultivated
- CA#8  Saline
- CA#9  Other

### RUN-OFF

- DA#1  None
- DA#2  Very Slow
- DA#3  Slow
- DA#4  Moderately Rapid
- DA#5  Rapid
- DA#6  Very Rapid

### INTERNAL DRAINAGE

- #### PERMEABILITY
- EA#1  Slowly Permeable
  - EA#2  Moderately Permeable
  - EA#3  Highly Permeable

### DRAINAGE

- EB#1  Very Poorly Drained
- EB#2  Poorly Drained
- EB#3  Imperfectly Drained
- EB#4  Moderately Well Drained
- EB#5  Well Drained
- EB#6  Rapidly Drained

### ROCK OUTCROP

- FA#1  None
- FA#2  < 10%
- FA#3  10 - 50%
- FA#4  > 50%

### EROSION

#### STATE OF EROSION

- GA#1  Active
- GA#2  Stabilized
- GA#3  Partly Stabilized

### WIND EROSION

- GB#1  None
- GB#2  Minor
- GB#3  Moderate
- GB#4  Severe
- GB#5  Very Severe

### WATER EROSION

- GC#1  No Sheet Erosion
- GC#2  Minor Sheet Erosion
- GC#3  Moderate Sheet Erosion
- GC#4  Severe Sheet Erosion
- GD#1  No Rill Erosion
- GD#2  Minor Rill Erosion
- GD#3  Moderate Rill Erosion
- GD#4  Severe Rill Erosion
- GE#1  No Gully Erosion
- GE#2  Minor Gully Erosion
- GE#3  Moderate Gully Erosion
- GE#4  Severe Gully Erosion

### GULLY EROSION DEPTH

- GF#1  < 1.5m
- GF#2  1.5 - 3.0m
- GF#3  > 3.0m

### WATER EROSION

- GG#1  No Tunnel Erosion
- GG#2  Tunnel Erosion
- GH#1  No Streambank Erosion
- GH#2  Streambank Erosion
- GJ#1  No Wave Erosion
- GJ#2  Wave Erosion
- GK#1  No Mass Movement
- GK#2  Mass Movement
- GL#1  Other Erosion

### DISTURBANCE OF SITE

- HA#1  No Effective Disturbance (NED)
- HA#2  NED Except Hooped Animals
- HA#3  Limited Clearing
- HA#4  Extensive Clearing
- HA#5  Complete Clearing, Pasture, Never Cultivated
- HA#6  Complete Clearing, Pasture, Cultivated
- HA#7  Cultivation Dryland
- HA#8  Cultivation Irrigated Past / Present
- HA#9  Highly Disturbed

### SUBSTRATE MATERIAL

#### STRENGTH

- IA#1  Very Weak
- IA#2  Weak
- IA#3  Moderate
- IA#4  Strong
- IA#5  Very Strong

Soil Parent Material	LITHOLOGY	Underlying Material
IB#1	Not Identified	IC#1
IB#2	Igneous	IC#2
IB#3	Serpentine	IC#3
IB#4	Oxirite	IC#4
IB#5	Granodiorite	IC#5
IB#6	Granite	IC#6
IB#7	Basalt / Diorite	IC#7
IB#8	Andesite	IC#8
IB#9	Trachyte / Syenite	IC#9
IB#10	Rhyolite	IC#10
IB#11	Sedimentary	IC#11
IB#12	Conglomerate	IC#12
IB#13	Sandstone	IC#13
IB#14	Shale	IC#14
IB#15	Mudstone / Siltstone	IC#15
IB#16	Limestone	IC#16
IB#17	Metamorphic	IC#17
IB#18	Amphibolite / Gneiss	IC#18
IB#19	Slate / Hornfels	IC#19
IB#20	Schist / Phyllite	IC#20
IB#21	Gneiss	IC#21
IB#22	Quartzite	IC#22
IB#23	Unconsolidated	IC#23
IB#24	Gravel	IC#24
IB#25	Sand	IC#25
IB#26	Silt	IC#26
IB#27	Clay	IC#27
IB#28	Other	IC#28

#### TYPE OF SOIL OBSERVATION

- JAB#1  Soil Pit
- JAB#2  Existing Vertical Exposure
- JAB#3  Soil Core
- JAB#4  Auger Boring

#### ADDENDUM


## NOTES RECORD

Record Type # # # 3	EXTENSIVE STRUCTURE DESTRUCTION IN A1 HOR IZON DUE TO CULTIVATION AT SITE E26

Figure 18 Example of cross-out site description sheet — front

# CROSS - OUT SITE DESCRIPTION SHEET HEADER RECORD

Record Type 0 0 0 1		Survey Code GEO		Site 52		Great Soil Group Code RBE		Principal Profile Form DC 2.23		Soil or Land Class	
Described by THOD		Air Photo		Reference		Date					
Film Number		Run No.		Frame No.		East		North		Day Month Year	
7		7778		33		207108		0386			
Map Sheet Number 853211111		Map Scale 1 50000		Map Zone S8M		Eastings / Latitude 46850		Northings / Longitude 6358050			
Slope Value 2.10%		Elevation (m) 278		Aspect ---		Depth of Regolith (m) 1.70		Depth of Standing Water (m) 1.70		Rainfall (mm) 552	

SEE NOTES

## LANDFORM, VEGETATION, LANDSURFACE, SUBSTRATE MATERIAL RECORD

Record Type 0 0 0 2
------------------------

**LANDFORM**  
LANDFORM ELEMENT MORPHOLOGICAL TYPE

AA#1	<input type="checkbox"/>	Crest
AA#2	<input type="checkbox"/>	Upper Slope
AA#3	<input type="checkbox"/>	Mid-Slope
AA#4	<input type="checkbox"/>	Lower Slope
AA#5	<input type="checkbox"/>	Simple Slope
AA#6	<input type="checkbox"/>	Flat
AA#7	<input type="checkbox"/>	Open Depression
AA#8	<input type="checkbox"/>	Closed Depression
AA#9	<input type="checkbox"/>	Hillock
AA#10	<input type="checkbox"/>	Ridge

**RUN-OFF**

DA#1	<input type="checkbox"/>	None
DA#2	<input type="checkbox"/>	Very Slow
DA#3	<input type="checkbox"/>	Slow
DA#4	<input type="checkbox"/>	Moderately Rapid
DA#5	<input type="checkbox"/>	Rapid
DA#6	<input type="checkbox"/>	Very Rapid

**DISTURBANCE OF SITE**

HAB#1	<input type="checkbox"/>	No Effective Disturbance (NED)
HAB#2	<input type="checkbox"/>	NED Escalated/Injured Animals
HAB#3	<input type="checkbox"/>	Limited Clearing
HAB#4	<input type="checkbox"/>	Extensive Clearing
HAB#5	<input type="checkbox"/>	Complete Clearing, Pasture, Animal Cultivated
HAB#6	<input type="checkbox"/>	Complete Clearing, Pasture, Cultivated
HAB#7	<input type="checkbox"/>	Cultivation Dryland
HAB#8	<input type="checkbox"/>	Cultivation Irrigated Past / Present
HAB#9	<input type="checkbox"/>	Highly Disturbed

**VEGETATION**  
TYPE OF FOREST

BA#1	<input checked="" type="checkbox"/>	Non-Rainforest
BA#2	<input type="checkbox"/>	Rainforest

**INTERNAL DRAINAGE PERMEABILITY**

EA#1	<input type="checkbox"/>	Slowly Permeable
EA#2	<input type="checkbox"/>	Moderately Permeable
EA#3	<input type="checkbox"/>	Highly Permeable

**SUBSTRATE MATERIAL STRENGTH**

JA#1	<input checked="" type="checkbox"/>	Very Weak
JA#2	<input checked="" type="checkbox"/>	Weak
JA#3	<input type="checkbox"/>	Moderate
JA#4	<input type="checkbox"/>	Strong
JA#5	<input type="checkbox"/>	Very Strong

**STRUCTURAL FORMATION CLASS**

BC#1	<input type="checkbox"/>	1
BC#2	<input type="checkbox"/>	2
BC#3	<input type="checkbox"/>	3
BC#4	<input type="checkbox"/>	4
BC#5	<input type="checkbox"/>	5
BC#6	<input type="checkbox"/>	6
BC#7	<input type="checkbox"/>	7
BC#8	<input type="checkbox"/>	8
BC#9	<input type="checkbox"/>	9
BC#10	<input type="checkbox"/>	10

**DRAINAGE**

EB#1	<input type="checkbox"/>	Very Poorly Drained
EB#2	<input type="checkbox"/>	Poorly Drained
EB#3	<input type="checkbox"/>	Imperfectly Drained
EB#4	<input type="checkbox"/>	Moderately Well Drained
EB#5	<input type="checkbox"/>	Well Drained
EB#6	<input type="checkbox"/>	Rapidly Drained

**LITHOLOGY**

IC#1	<input type="checkbox"/>	Not Identified
IC#2	<input checked="" type="checkbox"/>	Igneous
IC#3	<input type="checkbox"/>	Serpentine
IC#4	<input type="checkbox"/>	Diorite
IC#5	<input type="checkbox"/>	Granodiorite
IC#6	<input type="checkbox"/>	Granite
IC#7	<input type="checkbox"/>	Basalt / Diorite
IC#8	<input type="checkbox"/>	Andesite
IC#9	<input checked="" type="checkbox"/>	Trachyte / Syenite
IC#10	<input type="checkbox"/>	Rhyolite
IC#11	<input type="checkbox"/>	Sedimentary
IC#12	<input type="checkbox"/>	Conglomerate
IC#13	<input type="checkbox"/>	Sandstone
IC#14	<input type="checkbox"/>	Shale
IC#15	<input type="checkbox"/>	Mudstone / Siltstone
IC#16	<input type="checkbox"/>	Limestone
IC#17	<input type="checkbox"/>	Metamorphic
IC#18	<input type="checkbox"/>	Amphibolite / Greenstone
IC#19	<input type="checkbox"/>	Slate / Micrites
IC#20	<input type="checkbox"/>	Schist / Phyllite
IC#21	<input type="checkbox"/>	Gneiss
IC#22	<input type="checkbox"/>	Quartzite
IC#23	<input type="checkbox"/>	Unconsolidated
IC#24	<input type="checkbox"/>	Gravel
IC#25	<input type="checkbox"/>	Sand
IC#26	<input type="checkbox"/>	Silt
IC#27	<input type="checkbox"/>	Clay
IC#28	<input type="checkbox"/>	Other

**Tree**

BC#1	<input type="checkbox"/>	Tree
BC#2	<input type="checkbox"/>	Tree Matline
BC#3	<input type="checkbox"/>	Shrub
BC#4	<input type="checkbox"/>	Heath Shrub
BC#5	<input type="checkbox"/>	Heath Shrub
BC#6	<input type="checkbox"/>	Chenopod Shrub
BC#7	<input type="checkbox"/>	Hummock Grass
BC#8	<input type="checkbox"/>	Tussock Grass
BC#9	<input type="checkbox"/>	Sedge
BC#10	<input type="checkbox"/>	Rush

**ROCK OUTCROP**

FA#1	<input type="checkbox"/>	None
FA#2	<input type="checkbox"/>	<10%
FA#3	<input type="checkbox"/>	10-50%
FA#4	<input type="checkbox"/>	>50%

**EROSION STATE OF EROSION**

GA#1	<input type="checkbox"/>	Active
GA#2	<input type="checkbox"/>	Stabilized
GA#3	<input type="checkbox"/>	Partly Stabilized

**WIND EROSION**

GB#1	<input type="checkbox"/>	None
GB#2	<input type="checkbox"/>	Minor
GB#3	<input type="checkbox"/>	Moderate
GB#4	<input type="checkbox"/>	Severe
GB#5	<input type="checkbox"/>	Very Severe

**WATER EROSION**

GC#1	<input type="checkbox"/>	No Sheet Erosion
GC#2	<input type="checkbox"/>	Minor Sheet Erosion
GC#3	<input type="checkbox"/>	Moderate Sheet Erosion
GC#4	<input type="checkbox"/>	Severe Sheet Erosion
GD#1	<input type="checkbox"/>	No Rill Erosion
GD#2	<input type="checkbox"/>	Minor Rill Erosion
GD#3	<input type="checkbox"/>	Moderate Rill Erosion
GD#4	<input type="checkbox"/>	Severe Rill Erosion
GE#1	<input type="checkbox"/>	No Gully Erosion
GE#2	<input type="checkbox"/>	Minor Gully Erosion
GE#3	<input type="checkbox"/>	Moderate Gully Erosion
GE#4	<input type="checkbox"/>	Severe Gully Erosion

**UPPER STRATUM HEIGHT CLASS**

BD#1	<input type="checkbox"/>	>35.01m
BD#2	<input type="checkbox"/>	20.01-35m
BD#3	<input type="checkbox"/>	12.01-20m
BD#4	<input type="checkbox"/>	6.01-12m
BD#5	<input type="checkbox"/>	3.01-6m
BD#6	<input type="checkbox"/>	1.01-3m
BD#7	<input type="checkbox"/>	0.51-1m
BD#8	<input type="checkbox"/>	0.26-0.5m
BD#9	<input type="checkbox"/>	<0.25m

**DOMINANT SPECIES**

BE#1	<input type="checkbox"/>	1
BE#2	<input type="checkbox"/>	2
BE#3	<input type="checkbox"/>	3

**LANDSURFACE CONDITION OF SURFACE SOIL**

CA#1	<input checked="" type="checkbox"/>	Periodic Cracking
CA#2	<input type="checkbox"/>	Soil Mulching
CA#3	<input type="checkbox"/>	Loose
CA#4	<input type="checkbox"/>	Soil
CA#5	<input type="checkbox"/>	Firm
CA#6	<input checked="" type="checkbox"/>	Hard Setting
CA#7	<input type="checkbox"/>	Surface Crust
CA#8	<input type="checkbox"/>	Recently Cultivated
CA#9	<input type="checkbox"/>	Saline
CA#10	<input type="checkbox"/>	Other

**GULLY EROSION DEPTH**

GF#1	<input type="checkbox"/>	<1.5m
GF#2	<input type="checkbox"/>	1.5-3.0m
GF#3	<input type="checkbox"/>	>3.0m

**WATER EROSION**

GG#1	<input type="checkbox"/>	No Tunnel Erosion
GG#2	<input type="checkbox"/>	Tunnel Erosion
GH#1	<input type="checkbox"/>	No Streambank Erosion
GH#2	<input type="checkbox"/>	Streambank Erosion
GJ#1	<input type="checkbox"/>	No Wave Erosion
GJ#2	<input type="checkbox"/>	Wave Erosion
GK#1	<input type="checkbox"/>	No Mass Movement
GK#2	<input type="checkbox"/>	Mass Movement
GL#1	<input type="checkbox"/>	Other Erosion

**TYPE OF SOIL OBSERVATION**

JA#1	<input type="checkbox"/>	Soil Pit
JA#2	<input type="checkbox"/>	Existing Vertical Exposure
JA#3	<input type="checkbox"/>	Soil Core
JA#4	<input checked="" type="checkbox"/>	Auger Boring

**ADDENDUM**


**BOREHOLE E22  
ASC # 1**

Record Type 0 0 0 3
------------------------

## NOTES RECORD

TOP OF CORE SAMPLE MISSING - SOIL ASSUMED TO BE A DUPEL BASED ON SITE 53.

Figure 18 Example of cross-out site description sheet — front

SITE SZ cont.

# SOIL PROFILE RECORD 'A'

Layer No.	Horizon	Lower Average Depth (m)	Dominant Colour (Munsell Code)		Mottle						pH	
			Moist	Dry	Primary			Secondary				
1	A1	0.22	S.01YR	4.6								7.5
2	A2	0.35	S.01YR	4.6								8.0
3	B1	0.66	S.01YR	4.6								8.5
4	B2	1.70	S.01YR	4.6								9.0
5	C1											
6												

states

Record Type  
a g s 3

# SOIL PROFILE RECORD 'B'

## FIELD TEXTURE

### SAND FRACTION

MA#1	1	2	3	4	5	6	Fine
MA#2							Coarse

### GRADE

MB#1	1	2	3	4	5	6	Sand
MB#2							Loamy Sand
MB#3							Clayey Sand
MC#1							Sandy Loam
MC#2							Fine Sandy Loam
MC#3							Light Sandy Clay Loam
MD#1							Loam
MD#2							Loam, Fine Sandy
MD#3							Silt Loam
MD#4							Sandy Clay Loam
ME#1							Clay Loam
ME#2							Silty Clay Loam
ME#3							Fine Sandy Clay
MF#1							Sandy Clay Loam
MF#2							Silty Clay
MF#3							Light Clay
MF#4							Light Medium Clay
MG#1							Medium Clay
MG#2							Heavy Clay

### COARSE FRAGMENTS

#### ABUNDANCE

NA#1	1	2	3	4	5	6	None
NA#2							0-2%
NA#3							2-10%
NA#4							10-20%
NA#5							25-50%
NA#6							50-90%
NA#7							>90%

### SHAPE

NB#1	1	2	3	4	5	6	Rounded
NB#2							Subrounded
NB#3							Subangular
NB#4							Angular

### DISTRIBUTION

NC#1	1	2	3	4	5	6	Reoriented
NC#2							Undisturbed
NC#3							Stratified
NC#4							Dispersed

### SIZE

NO#1	1	2	3	4	5	6	2-6 mm
NO#2							6-20 mm
NO#3							20-50 mm
NO#4							60-200 mm
NO#5							200-600 mm
NO#6							>600 mm

### LITHOLOGY

NE#1	1	2	3	4	6	Quartz
NE#2						Igneous
NE#3						Sedimentary
NE#4						Metamorphic
NE#5						Same As Parent Material
NE#6						Not Identified

## STRUCTURE

### GRADE

PA#1	1	2	3	4	5	6	Apedal Single
PA#2							Apedal Massive
PA#3							Weak Pedality
PA#4							Moderate Pedality
PA#5							Strong Pedality

### PED SIZE

PC#1	1	2	3	4	5	6	<2mm
PC#2							2-5mm
PC#3							5-10mm
PC#4							10-20mm
PC#5							20-50mm
PC#6							50-100mm
PC#7							100-200mm
PC#8							200-500mm
PC#9							>500mm

### PED TYPE

PE#1	1	2	3	4	5	6	Platy
PE#2							Prismatic
PE#3							Columnar
PE#4							Angular Blocky
PE#5							Subangular Blocky
PE#6							Polynear
PE#7							Lenticular
PE#8							Granular
PE#9							Cast

### FABRIC

QA#1	1	2	3	4	5	6	Earthy
QA#2							Sandy
QA#3							Smooth Ped
QA#4							Rough Ped

### CUTANS

RA#1	1	2	3	4	5	6	None
RA#2							Few (<10%)
RA#3							Common (10-50%)
RA#4							Many (>50%)

### VOIDS

SA#1	1	2	3	4	5	6	Macropores
SA#2							No macropores

### CRACK WIDTH

SB#1	1	2	3	4	5	6	<5mm
SB#2							5-10mm
SB#3							10-20mm
SB#4							20-50mm
SB#5							>50mm

### CONSISTENCE

TA#1	1	2	3	4	5	6	Loose
TA#2							Very weak
TA#3							Moderately Weak
TA#4							Moderately Firm
TA#5							Very Firm
TA#6							Moderately Strong
TA#7							Very Strong
TA#8							Rigid

### PLASTICITY TYPE

TB#1	1	2	3	4	5	6	Superplastic
TB#2							Normal Plastic
TB#3							Subplastic
TB#4							Strongly Plastic

### STICKINESS

TC#1	1	2	3	4	5	6	Non Sticky
TC#2							Slightly Sticky
TC#3							Moderately Sticky
TC#4							Very Sticky

## PANS

### CEMENTATION

UA#1	1	2	3	4	5	6	Uncemented
UA#2							Weakly Cemented
UA#3							Moderately Cemented
UA#4							Strongly Cemented
UA#5							Very Strongly Cemented

### TYPE

UB#1	1	2	3	4	5	6	No Pans
UB#2							Calcrete
UB#3							Silcrete
UB#4							Iron Pan
UB#5							Sesquioxide Pan
UB#6							Ortstein
UB#7							Coffee Rock
UB#8							Other

### CONTINUITY

UC#1	1	2	3	4	5	6	Continuous
UC#2							Discontinuous
UC#3							Broken

### SEGREGATIONS

#### ABUNDANCE

VA#1	1	2	3	4	5	6	0
VA#2							<2%
VA#3							2-10%
VA#4							10-20%
VA#5							20-50%
VA#6							>50%

### NATURE

VB#1	1	2	3	4	5	6	Calcareous
VB#2							Cyanous
VB#3							Ferruginous
VB#4							Manganiferous
VB#5							Organic
VB#6							Other

### FORM

VC#1	1	2	3	4	5	6	Nodules
VC#2							Crystals
VC#3							Soft Segregations

### SIZE

VD#1	1	2	3	4	5	6	<2mm
VD#2							2-6mm
VD#3							6-20mm
VD#4							20-60mm
VD#5							>60mm

### ROOTS

WA#1	1	2	3	4	5	6	None
WA#2							Few
WA#3							Common
WA#4							Many
WA#5							Abundant

### BOUNDARY

#### DISTINCTNESS

XA#1	1	2	3	4	5	6	Sharp (<5mm)
XA#2							Abrupt (5-20mm)
XA#3							Clear (20-50mm)
XA#4							Gradual (50-100mm)
XA#5							Diffuse (>100mm)

### SHAPE

XB#1	1	2	3	4	5	6	Smooth
XB#2							Wavy
XB#3							Irregular
XB#4							Broken

UNKNOWN

Figure 19 Example of cross-out site description sheet — reverse

# CROSS-OUT SITE DESCRIPTION SHEET HEADER RECORD

Record Type # # # 1		Survey Code GEO		Site 83		Great Survey Group Code KBE DC 2.13		Principal Profile Form		Soil or Land Class	
Described by THOD		Air Photo		Reference		Date					
Firm Number		Run No.		Frame No.		East		North		Day	
		7778		87		1950		08		28	
Map Sheet Number		Map Scale		Map Zone		Map Reference					
8332 11 + 111		50000		55 M 59		900635 7800					
Slope Value		Elevation (m)		Aspect		Depth of Regolith (m)		Depth of Standing Water		Remitt (mm)	
51.00		27.8		-		1.40		1.40		552	

## LANDFORM, VEGETATION, LANDSURFACE, SUBSTRATE MATERIAL RECORD

**LANDFORM**  
LANDFORM ELEMENT MORPHOLOGICAL TYPE

AA81  Crest  
AA82  Upper Slope  
AA83  Mid-Slope  
AA84  Lower Slope  
AA85  Steep Slope  
AA86  Flat  
AA87  Open Depression  
AA88  Closed Depression  
AA89  Hilltop  
AA19  Ridge

**RUN-OFF**

DA81  None  
DA82  Very Slow  
DA83  Slow  
DA84  Moderately Rapid  
DA85  Rapid  
DA86  Very Rapid

**INTERNAL DRAINAGE**  
**PERMEABILITY**

EA81  Slowly Permeable  
EA82  Moderately Permeable  
EA83  Highly Permeable

*becomes so as cracks close up.*

**DISTURBANCE OF SITE**

HAB1  No Effective Disturbance (NED)  
HAB2  NED Except Hoofed Animals  
HAB3  Limited Clearing  
HAB4  Extensive Clearing  
HAB5  Complete Clearing, Pasture, Never Cultivated  
HAB6  Complete Clearing, Pasture, Cultivated  
HAB7  Cultivation Dryland  
HAB8  Cultivation Irrigated Past/ Present  
HAB9  Highly Disturbed

**VEGETATION**  
**TYPE OF FOREST**

BA81  Non-Reinforest  
BA82  Reinforest

**DRAINAGE**

EB81  Very Poorly Drained  
EB82  Poorly Drained  
EB83  Imperfectly Drained  
EB84  Moderately Well Drained  
EB85  Well Drained  
EB86  Rapidly Drained

**SUBSTRATE MATERIAL**  
**STRENGTH**

IA81  Very Weak  
IA82  Weak  
IA83  Moderate  
IA84  Strong  
IA85  Very Strong

**STRUCTURAL FORMATION CLASS**

1	2	3	4	5	6
BC81					
BC82					
BC83					
BC84					
BC85					
BC86					
BC87					
BC88					
BC89					
BC19					

**ROCK OUTCROP**

FA81  None  
FA82  <10%  
FA83  10-50%  
FA84  >50%

Soil Parent Material	LITHOLOGY	Underlying Material
IB81	Not identified	IC81
IB82	Tuff	IC82
IB83	Serpentine	IC83
IB84	Diorite	IC84
IB85	Gneiss	IC85
IB86	Granite	IC86
IB87	Basalt / Dolerite	IC87
IB88	Andesite	IC88
IB89	Trachyte / Syenite	IC89
IB90	Rhyolite	IC90
ID81	Sedimentary	IE81
ID82	Conglomerate	IE82
ID83	Sandstone	IE83
ID84	Shale	IE84
ID85	Mudstone / Siltstone	IE85
ID86	Limestone	IE86
IF81	Metamorphic	IG81
IF82	Amphibolite / Greenstone	IG82
IF83	Slate / hornfels	IG83
IF84	Schist / Phyllite	IG84
IF85	Gneiss	IG85
IF86	Quartzite	IG86
IJ81	Unconsolidated	IK81
IJ82	Gravel	IK82
IJ83	Sand	IK83
IJ84	Silt	IK84
IJ85	Clay	IK85
IJ86	Other	IK86

**UPPER STRATUM HEIGHT CLASS**

BD81	>35.01m
BD82	20.01 - 35m
BD83	12.01 - 20m
BD84	6.01 - 12m
BD85	3.01 - 6m
BD86	1.01 - 3m
OD87	0.51 - 1m
OD88	0.26 - 0.5m
OD89	< 0.25m

**EROSION**  
**STATE OF EROSION**

GA81  Active  
GA82  Stabilized  
GA83  Partly Stabilized

**WIND EROSION**

GB81  None  
GB82  Minor  
GB83  Moderate  
GB84  Severe  
GB85  Very Severe

**DOMINANT SPECIES**

BE81	1	2	3	4	5	6
BE82						
BE83						

**LANDSURFACE**  
**CONDITION OF SURFACE SOIL**

CA81  Periotic Cracking  
CA82  Soil Mulching  
CA83  Loose  
CA84  Silt  
CA85  Firm  
CA86  Hard Setting  
CA87  Surface Crust  
CA88  Recently Cultivated  
CA89  Saline  
CA19  Other

**WATER EROSION**

GD81  No Sheet Erosion  
GD82  Minor Sheet Erosion  
GD83  Moderate Sheet Erosion  
GD84  Severe Sheet Erosion  
GD85  No Rill Erosion  
GD86  Minor Rill Erosion  
GD87  Moderate Rill Erosion  
GD88  Severe Rill Erosion  
GE81  No Gully Erosion  
GE82  Minor Gully Erosion  
GE83  Moderate Gully Erosion  
GE84  Severe Gully Erosion

**GULLY EROSION DEPTH**

GF81  < 1.5m  
GF82  1.5 - 3.0m  
GF83  > 3.0m

**WATER EROSION**

GG81  No Tunnel Erosion  
GG82  Tunnel Erosion  
GH81  No Streambank Erosion  
GH82  Streambank Erosion  
GJ81  No Wave Erosion  
GJ82  Wave Erosion  
GK81  No Mass Movement  
GK82  Mass Movement  
GL81  Other Erosion

**TYPE OF SOIL OBSERVATION**

JAB1  Soil Pit  
JAB2  Existing Vertical Exposure  
JAB3  Soil Core  
JAB4  Auger Boring

**ADDENDUM**


**Record Type**  
# # # 3

SUMP AT E22


## NOTES RECORD

Figure 18 Example of cross-out site description sheet — front

SITE 53 cont.

### SOIL PROFILE RECORD 'A'

No A<sub>2</sub> present. Plough Pan at 10cm depth.

Layer No.	Horizon	Lower Average Depth (m)	Dominant Colour (Munsell Code)				Mottle					pH
			Moist		Dry		Primary			Secondary		
			Abund	Size	Contr	Colour	Abund	Size	Contr	Colour	Soil Water Sat.	
1	A	1.10	2.5	YR	3.4							6.5
2	A <sub>1</sub>	3.0	5.0	YR	3.4							7.5
3	B <sub>1</sub>	7.6	2.5	YR	4.6							8.5
4	B <sub>2</sub>	14.0	5.0	YR	4.6							9.0
5												
6												

Record Type  
g g g 5

### SOIL PROFILE RECORD 'B'

#### FIELD TEXTURE

##### SAND FRACTION

MA#1	1	2	3	4	5	6	Fine
MA#1							
MA#2							Coarse

##### GRADE

MB#1	1	2	3	4	5	6	Sand
MB#1							
MB#2							Loamy Sand
MB#3							Clayey Sand
MB#4							Sandy Loam
MC#1							Fine Sandy Loam
MC#2							Light Sandy Clay
MD#1							Loam
MD#2							Lim. Fine Sandy
MD#3							Silt Loam
MD#4							Sandy Clay Loam
ME#1							Clay Loam
ME#2							Silty Clay Loam
ME#3							Fine Sandy Clay
ME#4							Sandy Clay Loam
MF#1							Silty Clay
MF#2							Silty Clay
MF#3							Light Clay
MF#4							Light Medium Clay
MG#1							Medium Clay
MG#2							Heavy Clay

#### COARSE FRAGMENTS

##### ABUNDANCE

NA#1	0	1	2	3	4	5	6	None
NA#1								
NA#2								0-2%
NA#3								2-10%
NA#4								10-20%
NA#5								25-50%
NA#6								50-90%
NA#7								>90%

##### SHAPE

NB#1	0	1	2	3	4	5	6	Rounded
NB#1								
NB#2								Subrounded
NB#3								Subangular
NB#4								Angular

##### DISTRIBUTION

NC#1	0	1	2	3	4	5	6	Reoriented
NC#1								
NC#2								Undisturbed
NC#3								Stratified
NC#4								Dispersed

##### SIZE

NB#1	0	1	2	3	4	5	6	2-6 mm
NB#1								
NB#2								6-20mm
NB#3								20-60 mm
NB#4								60-200mm
NB#5								200-600mm
NB#6								>600mm

##### LITHOLOGY

NE#1	0	1	2	3	4	5	6	Quartz
NE#1								
NE#2								Igneous
NE#3								Sedimentary
NE#4								Metamorphic
NE#5								Same As Parent Material
NE#6								Not Identified

#### STRUCTURE

##### GRADE

PA#1	1	2	3	4	5	6	Primary	PB#1	1	2	3	4	5	6	Secondary
PA#1							Pedal Single	PB#1							
PA#2							Pedal Massive	PB#2							
PA#3							Weak Pedality	PB#3							
PA#4							Moderate Pedality	PB#4							
PA#5							Strong Pedality	PB#5							

##### PED SIZE

PC#1	1	2	3	4	5	6	Primary	PD#1	1	2	3	4	5	6	Secondary
PC#1							<2mm	PD#1							
PC#2							2-5mm	PD#2							
PC#3							5-10mm	PD#3							
PC#4							10-20mm	PD#4							
PC#5							20-50mm	PD#5							
PC#6							50-100mm	PD#6							
PC#7							100-200mm	PD#7							
PC#8							200-500mm	PD#8							
PC#9							>500mm	PD#9							

##### PED TYPE

PE#1	1	2	3	4	5	6	Primary	PF#1	1	2	3	4	5	6	Secondary
PE#1							Platy	PF#1							
PE#2							Prismatic	PF#2							
PE#3							Columnar	PF#3							
PE#4							Angular Blocky	PF#4							
PE#5							Subangular Blocky	PF#5							
PE#6							Polyhedral	PF#6							
PE#7							Lenticular	PF#7							
PE#8							Granular	PF#8							
PE#9							Cast	PF#9							

##### FABRIC

QA#1	1	2	3	4	5	6
QA#1						
QA#2						
QA#3						
QA#4						

##### CUTANS

RA#1	1	2	3	4	5	6
RA#1						
RA#2						
RA#3						
RA#4						

##### VOIDS

SA#1	1	2	3	4	5	6
SA#1						
SA#2						

##### CRACK WIDTH

SB#1	1	2	3	4	5	6
SB#1						
SB#2						
SB#3						
SB#4						
SB#5						

##### CONSISTENCE

TA#1	1	2	3	4	5	6
TA#1						
TA#2						
TA#3						
TA#4						
TA#5						
TA#6						
TA#7						
TA#8						

##### PLASTICITY TYPE

TB#1	1	2	3	4	5	6
TB#1						
TB#2						
TB#3						
TB#4						

##### STICKINESS

TC#1	1	2	3	4	5	6
TC#1						
TC#2						
TC#3						
TC#4						

#### PANS

##### CEMENTATION

UA#1	1	2	3	4	5	6
UA#1						
UA#2						
UA#3						
UA#4						
UA#5						

##### TYPE

UB#1	1	2	3	4	5	6
UB#1						
UB#2						
UB#3						
UB#4						
UB#5						
UB#6						
UB#7						
UB#8						

##### CONTINUITY

UC#1	1	2	3	4	5	6
UC#1						
UC#2						
UC#3						

##### SEGREGATIONS

##### ABUNDANCE

VA#1	0	1	2	3	4	5	6
VA#1							
VA#2							
VA#3							
VA#4							
VA#5							
VA#6							

##### NATURE

VB#1	1	2	3	4	5	6
VB#1						
VB#2						
VB#3						
VB#4						
VB#5						
VB#6						

##### FORM

VC#1	1	2	3	4	5	6
VC#1						
VC#2						
VC#3						

##### SIZE

VD#1	1	2	3	4	5	6
VD#1						
VD#2						
VD#3						
VD#4						
VD#5						

##### ROOTS

WA#1	1	2	3	4	5	6
WA#1						
WA#2						
WA#3						
WA#4						
WA#5						

##### BOUNDARY

##### DISTINCTNESS

XA#1	1	2	3	4	5	6
XA#1						
XA#2						
XA#3						
XA#4						
XA#5						

##### SHAPE

XB#1	1	2	3	4	5	6
XB#1						
XB#2						
XB#3						
XB#4						

Plough Pan at 10cm.

Figure 19 Example of cross-out site description sheet — reverse

# CROSS-OUT SITE DESCRIPTION SHEET

## HEADER RECORD

Record Type <b>0 0 0 1</b>		Survey Code <b>GEO</b>		Site <b>54</b>		Great Soil Group Code <b>R5EDC2-13</b>		Principal Profile Form		Soil or Land Class	
Described by <b>TR0D</b>		Photo		Reference		Date					
Firm Number		Run No.		Frame No.		East		North		Year	
		<b>7</b>		<b>7718</b>		<b>61</b>		<b>16308</b>		<b>0386</b>	
Map Sheet Number		Map Scale 1		Map Zone		Map Reference		Eastings / Latitude		Northings / Longitude	
<b>853211111</b>		<b>50000</b>		<b>55M</b>		<b>597400</b>		<b>6356850</b>			
Slope Value		Elevation (m)		Aspect		Depth of Rooting (m)		Depth of Standing Water		Basalt (mm)	
<b>2.0%</b>		<b>282250</b>		<b>90-</b>		<b>.90</b>		<b>.552</b>			

## LANDFORM, VEGETATION, LANDSURFACE, SUBSTRATE MATERIAL RECORD

Record Type  
**0 0 0 2**

**LANDFORM**  
LANDFORM ELEMENT MORPHOLOGICAL TYPE

AA#1  Crest  
AA#2  Upper Slope  
AA#3  Mid-Slope  
AA#4  Lower Slope  
AA#5  Simple Slope *long!*  
AA#6  Flat  
AA#7  Open Depression  
AA#8  Closed Depression  
AA#9  Hilltop  
AA#10  Ridge

**VEGETATION**  
TYPE OF FOREST

BA#1  Non-Rainforest  
BA#2  Rainforest

**STRUCTURAL FORMATION CLASS**

BC#1	<input checked="" type="checkbox"/>	Tree
BC#2	<input type="checkbox"/>	Tree Mallee
BC#3	<input type="checkbox"/>	Shrub
BC#4	<input type="checkbox"/>	Mallee Shrub
BC#5	<input type="checkbox"/>	Heath Shrub
BC#6	<input type="checkbox"/>	Chenopod Shrub
BC#7	<input type="checkbox"/>	Hummock Shrub
BC#8	<input type="checkbox"/>	Tussock Grass
BC#9	<input type="checkbox"/>	Sedge
BC#10	<input type="checkbox"/>	Rush

**UPPER STRATUM HEIGHT CLASS**

BD#1	<input type="checkbox"/>	>35.0m
BD#2	<input type="checkbox"/>	20.01-35m
BD#3	<input type="checkbox"/>	12.01-20m
BD#4	<input checked="" type="checkbox"/>	6.01-12m
BD#5	<input type="checkbox"/>	3.01-6m
BD#6	<input type="checkbox"/>	1.01-3m
BD#7	<input type="checkbox"/>	0.51-1m
BD#8	<input type="checkbox"/>	0.26-0.5m
BD#9	<input type="checkbox"/>	<0.25m

**DOMINANT SPECIES**

BE#1  *Callitris*  
BE#2   
BE#3

**LANDSURFACE**  
CONDITION OF SURFACE SOIL

CA#1  Periodic Cracking *Not as prevalent as 53*  
CA#2  Soil Mushing  
CA#3  Loose  
CA#4  Soft  
CA#5  Firm  
CA#6  Hard Setting  
CA#7  Surface Crust  
CA#8  Recently Cultivated  
CA#9  Saline  
CA#10  Other

**RUN-OFF**

DA#1  None  
DA#2  Very Slow  
DA#3  Slow  
DA#4  Moderately Rapid  
DA#5  Rapid  
DA#6  Very Rapid

**INTERNAL DRAINAGE**  
**PERMEABILITY**

EA#1  Slowly Permeable  
EA#2  Moderately Permeable  
EA#3  Highly Permeable

**DRAINAGE**

EB#1  Very Poorly Drained  
EB#2  Poorly Drained  
EB#3  Imperfectly Drained  
EB#4  Moderately Well Drained  
EB#5  Well Drained  
EB#6  Rapidly Drained

**ROCK OUTCROP**

FA#1  None  
FA#2  <10%  
FA#3  10-50%  
FA#4  >50%

**EROSION**  
**STATE OF EROSION**

GA#1  Active  
GA#2  Stabilized  
GA#3  Partly Stabilized

**WIND EROSION**

GB#1  None  
GB#2  Minor  
GB#3  Moderate  
GB#4  Severe  
GB#5  Very Severe

**WATER EROSION**

GC#1  No Sheet Erosion  
GC#2  Minor Sheet Erosion  
GC#3  Moderate Sheet Erosion  
GC#4  Severe Sheet Erosion  
GD#1  No Rill Erosion  
GD#2  Minor Rill Erosion  
GD#3  Moderate Rill Erosion  
GD#4  Severe Rill Erosion  
GE#1  No Gully Erosion  
GE#2  Minor Gully Erosion  
GE#3  Moderate Gully Erosion  
GE#4  Severe Gully Erosion

**GULLY EROSION DEPTH**

GF#1  <1.5m  
GF#2  1.5-3.0m  
GF#3  >3.0m

**WATER EROSION**

GH#1  No Tunnel Erosion  
GH#2  Tunnel Erosion  
GH#3  No Streambank Erosion  
GH#4  Streambank Erosion  
GJ#1  No Wave Erosion  
GJ#2  Wave Erosion  
GK#1  No Mass Movement  
GK#2  Mass Movement  
GL#1  Other Erosion

**DISURBANCE OF SITE**

HAB#1  No Effective Disturbance (NED)  
HAB#2  NED Except Hoofed Animals  
HAB#3  Limited Clearing  
HAB#4  Extensive Clearing  
HAB#5  Complete Clearing, Pasture, Never Cultivated  
HAB#6  Complete Clearing, Pasture, Cultivated  
HAB#7  Cultivation Dryland  
HAB#8  Cultivation Irrigated Past / Present  
HAB#9  Highly Disturbed

**SUBSTRATE MATERIAL**  
**STRENGTH**

IA#1  Very Weak  
IA#2  Weak  
IA#3  Moderate  
IA#4  Strong  
IA#5  Very Strong

*Not Found.*

Soil Parent Material	LITHOLOGY	Underlying Material
IB#1 <input checked="" type="checkbox"/>	Not identified igneous	IC#1 <input checked="" type="checkbox"/>
IB#2 <input type="checkbox"/>	Serpentine	IC#2 <input type="checkbox"/>
IB#3 <input type="checkbox"/>	Diorite	IC#3 <input type="checkbox"/>
IB#4 <input type="checkbox"/>	Granodiorite	IC#4 <input type="checkbox"/>
IB#5 <input type="checkbox"/>	Granite	IC#5 <input type="checkbox"/>
IB#6 <input type="checkbox"/>	Basalt / Diorite	IC#6 <input type="checkbox"/>
IB#7 <input type="checkbox"/>	Andesite	IC#7 <input type="checkbox"/>
IB#8 <input type="checkbox"/>	Trachyte / Syenite	IC#8 <input type="checkbox"/>
IB#9 <input type="checkbox"/>	Rhyolite	IC#9 <input type="checkbox"/>
IB#10 <input type="checkbox"/>	Sedimentary	IC#10 <input type="checkbox"/>
IB#11 <input type="checkbox"/>	Conglomerate	IC#11 <input type="checkbox"/>
IB#12 <input type="checkbox"/>	Sandstone	IC#12 <input type="checkbox"/>
IB#13 <input type="checkbox"/>	Shale	IC#13 <input type="checkbox"/>
IB#14 <input type="checkbox"/>	Mudstone / Siltstone	IC#14 <input type="checkbox"/>
IB#15 <input type="checkbox"/>	Limestone	IC#15 <input type="checkbox"/>
IB#16 <input type="checkbox"/>	Metamorphic	IC#16 <input type="checkbox"/>
IB#17 <input type="checkbox"/>	Amphibolite / Greenstone	IC#17 <input type="checkbox"/>
IB#18 <input type="checkbox"/>	Slate / Gneiss	IC#18 <input type="checkbox"/>
IB#19 <input type="checkbox"/>	Schist / Phyllite	IC#19 <input type="checkbox"/>
IB#20 <input type="checkbox"/>	Quartzite	IC#20 <input type="checkbox"/>
IB#21 <input type="checkbox"/>	Unconsolidated	IC#21 <input type="checkbox"/>
IB#22 <input type="checkbox"/>	Gravel	IC#22 <input type="checkbox"/>
IB#23 <input type="checkbox"/>	Sand	IC#23 <input type="checkbox"/>
IB#24 <input type="checkbox"/>	Silt	IC#24 <input type="checkbox"/>
IB#25 <input type="checkbox"/>	Clay	IC#25 <input type="checkbox"/>
IB#26 <input type="checkbox"/>	Other	IC#26 <input type="checkbox"/>

**TYPE OF SOIL OBSERVATION**

JAB#1  Soil Pit  
JAB#2  Existing Vertical Exposure  
JAB#3  Soil Core  
JAB#4  Auger Boring

ADDENDUM


Record Type  
**0 0 0 3**

## NOTES RECORD

**AT SITE TP19 Limestone Forest - Current Harvesting Programme just completed**

Figure 18 Example of cross-out site description sheet — front

SITE S4 cont.

### SOIL PROFILE RECORD 'A'

Layer No.	Horizon	Lower Average Depth (m)	Dominant Colour (Munsell Code)				Mottle					pH		
			Moist		Dry		Primary			Secondary				
			Moist	Dry	Abund.	Size	Contr.	Colour	Abund.	Size	Contr.		Colour	
1	A1	20	10R	3/3	Dark Reddish Brown									6.0
2	B1	40	7.5R	3/4	Dark Red									7.0
3	B2	90	7.5R	3/4	Dark Red									7.5
4														8.0
5														
6														

Record Type  
# # # # 5

### SOIL PROFILE RECORD 'B'

#### FIELD TEXTURE

##### SAND FRACTION

MA#1	1	2	3	4	5	6	Fine
MA#2							Coarse

##### GRADE

MB#1	1	2	3	4	5	6	Sand
MB#2							Loamy Sand
MB#3							Clayey Sand
MC#1							Sandy Loam
MC#2							Fine Sandy Loam
MC#3							Light Sandy Clay
MD#1							Loam
MD#2							Loam, Fine Sandy
MD#3							Silt Loam
MD#4							Sandy Clay Loam
ME#1							Clay Loam
ME#2							Shaly Clay Loam
ME#3							Fine Sandy Clay
ME#4							Sandy Clay Loam
MF#1							Clay
MF#2							Light Clay
MF#3							Light Medium Clay
MG#1							Medium Clay
MG#2							Heavy Clay

##### COARSE FRAGMENTS

##### ABUNDANCE

NA#1	1	2	3	4	5	6	None
NA#2							0-2%
NA#3							2-10%
NA#4							10-20%
NA#5							25-50%
NA#6							50-90%
NA#7							>90%

##### SHAPE

NB#1	1	2	3	4	5	6	Rounded
NB#2							Subrounded
NB#3							Subangular
NB#4							Angular

##### DISTRIBUTION

NC#1	1	2	3	4	5	6	Reoriented
NC#2							Undisturbed
NC#3							Stratified
NC#4							Dispersed

##### SIZE

ND#1	1	2	3	4	5	6	2-6 mm
ND#2							6-20mm
ND#3							20-60 mm
ND#4							60-200mm
ND#5							200-600mm
ND#6							>600mm

##### LITHOLOGY

NE#1	1	2	3	4	5	6	Quartz
NE#2							Igneous
NE#3							Sedimentary
NE#4							Metamorphic
NE#5							Same As Parent Material
NE#6							Not Identified

#### STRUCTURE

##### GRADE

PA#1	1	2	3	4	5	6	Apical Single
PA#2							Apical Massive
PA#3							Weak Pedality
PA#4							Moderate Pedality
PA#5							Strong Pedality

##### PED SIZE

PC#1	1	2	3	4	5	6	<2mm
PC#2							2-5mm
PC#3							5-10mm
PC#4							10-20mm
PC#5							20-50mm
PC#6							50-100mm
PC#7							100-200mm
PC#8							200-500mm
PC#9							>500mm

##### PED TYPE

PE#1	1	2	3	4	5	6	Platy
PE#2							Prismatic
PE#3							Columnar
PE#4							Angular Blocky
PE#5							Subangular Blocky
PE#6							Polyhedral
PE#7							Lenticular
PE#8							Granular
PE#9							Cast

##### FABRIC

QA#1	1	2	3	4	5	6	Earthy
QA#2							Sandy
QA#3							Smooth Ped
QA#4							Rough Ped

##### CUTANS

RA#1	1	2	3	4	5	6	None
RA#2							Few (<10%)
RA#3							Common (10-50%)
RA#4							Many (>50%)

##### VOIDS

##### PORES

SA#1	1	2	3	4	5	6	Macropores
SA#2							No macropores

##### CRACK WIDTH

SB#1	1	2	3	4	5	6	<5mm
SB#2							5-10mm
SB#3							10-20mm
SB#4							20-50mm
SB#5							>50mm

##### CONSISTENCY

##### STRENGTH

TA#1	1	2	3	4	5	6	Loose
TA#2							Very Weak
TA#3							Moderately Weak
TA#4							Moderately Firm
TA#5							Very Firm
TA#6							Moderately Strong
TA#7							Very Strong
TA#8							Rigid

##### PLASTICITY TYPE

TB#1	1	2	3	4	5	6	Superplastic
TB#2							Normal Plastic
TB#3							Subplastic
TB#4							Strongly Plastic

##### STICKINESS

TC#1	1	2	3	4	5	6	Non Sticky
TC#2							Slightly Sticky
TC#3							Moderately Sticky
TC#4							Very Sticky

#### PANS

##### CEMENTATION

UA#1	1	2	3	4	5	6	Uncemented
UA#2							Weakly Cemented
UA#3							Moderately Cemented
UA#4							Strongly Cemented
UA#5							Very Strongly Cemented

##### TYPE

UB#1	1	2	3	4	5	6	No Pans
UB#2							Calcrete
UB#3							Silcrete
UB#4							Iron Pan
UB#5							Sesquioxide Pan
UB#6							Oxide Pan
UB#7							Carbon Rock
UB#8							Other

##### CONTINUITY

UC#1	1	2	3	4	5	6	Continuous
UC#2							Discontinuous
UC#3							Broken

##### SEGREGATIONS

##### ABUNDANCE

VA#1	1	2	3	4	5	6	0
VA#2							<2%
VA#3							2-10%
VA#4							10-20%
VA#5							20-50%
VA#6							>50%

##### NATURE

VB#1	1	2	3	4	5	6	Calcareous
VB#2							Gypaeous
VB#3							Ferruginous
VB#4							Manganiferous
VB#5							Organic
VB#6							Dimer

##### FORM

VC#1	1	2	3	4	5	6	Nodules
VC#2							Crystals
VC#3							Soft Segregations

##### SIZE

VD#1	1	2	3	4	5	6	<2mm
VD#2							2-6mm
VD#3							6-20mm
VD#4							20-60mm
VD#5							>60mm

##### ROOTS

WA#1	1	2	3	4	5	6	None
WA#2							Few
WA#3							Common
WA#4							Many
WA#5							Abundant

##### BOUNDARY DISTINCTNESS

XA#1	1	2	3	4	5	6	Sharp (<5mm)
XA#2							Abrupt (5-20mm)
XA#3							Clear (20-50mm)
XA#4							Gradual (50-100mm)
XA#5							Diffuse (>100mm)

##### SHAPE

XB#1	1	2	3	4	5	6	Smooth
XB#2							Wavy
XB#3							Irregular
XB#4							Broken

Figure 19 Example of cross-out site description sheet — reverse

# CROSS - OUT SITE DESCRIPTION SHEET

## HEADER RECORD

Record Type B, B, B, 1		Survey Code BEO		Site SS		Great Soil Group Code BC		Principal Profile Form		Soil or Land Class	
Described by THOD		Photo		Reference		Date					
Film Number		Run No.		Frame No.		East		North		Date	
		7778		85104		080388					
Map Sheet Number 8532117111		Map Scale 1: 50000		Map Zone 85M597600		Map Reference Eastings / Latitude		Northings / Longitude 6355700			
Slope Value E 2.0%		Elevation 280		Aspect 340		Depth of Regolith (m) 2.80		Depth of Standing Water 60		Rainfall (mm) 552	

## LANDFORM, VEGETATION, LANDSURFACE, SUBSTRATE MATERIAL RECORD

Record Type  
B, B, B, 2

### LANDFORM

LANDFORM ELEMENT MORPHOLOGICAL TYPE

- AA01  Crest
- AA02  Upper Slope
- AA03  Mid-Slope
- AA04  Lower Slope
- AA05  Simple Slope **LONG!**
- AA06  Flat
- AA07  Open Depression
- AA08  Closed Depression
- AA09  Hilllock
- AA10  Ridge

### RUN-OFF

- DA01  None
- DA02  Very Slow
- DA03  Slow
- DA04  Moderately Rapid
- DA05  Rapid
- DA06  Very Rapid

### INTERNAL DRAINAGE

- PERMEABILITY
- EA01  Slowly Permeable
  - EA02  Moderately Permeable
  - EA03  Highly Permeable

### DISTURBANCE OF SITE

- HAB1  No Effective Disturbance (NED)
- HAB2  NED Except Hoofed Animals
- HAB3  Limited Clearing
- HAB4  Extensive Clearing
- HAB5  Complete Clearing, Pasture Never Cultivated
- HAB6  Complete Clearing, Pasture Cultivated
- HAB7  Cultivation Dryland
- HAB8  Cultivation Irrigated Past / Present
- HAB9  Highly Disturbed

### SUBSTRATE MATERIAL

#### STRENGTH

- IA01  Very Weak
- IA02  Weak
- IA03  Moderate
- IA04  Strong
- IA05  Very Strong

} Not found

### VEGETATION

TYPE OF FOREST

- BA01  Non-Rainforest
- BA02  Rainforest

### STRUCTURAL FORMATION CLASS

BC01	<input checked="" type="checkbox"/>	Tree Mallee
BC02	<input type="checkbox"/>	Shrub
BC03	<input type="checkbox"/>	Mallee Shrub
BC04	<input type="checkbox"/>	Heath Shrub
BC05	<input type="checkbox"/>	Chenopod Shrub
BC06	<input type="checkbox"/>	Hummock Shrub
BC07	<input type="checkbox"/>	Tussock Grass
BC08	<input type="checkbox"/>	Sedge
BC09	<input type="checkbox"/>	Rush
BC10	<input type="checkbox"/>	

### DRAINAGE

- EB01  Very Poorly Drained
- EB02  Poorly Drained
- EB03  Imperfectly Drained
- EB04  Moderately Well Drained
- EB05  Well Drained
- EB06  Rapidly Drained

### ROCK OUTCROP

- FA01  None
- FA02  <10%
- FA03  10-50%
- FA04  >50%

### EROSION

STATE OF EROSION

- GA01  Active
- GA02  Stabilized
- GA03  Partly Stabilized

### WIND EROSION

- GB01  None
- GB02  Minor
- GB03  Moderate
- GB04  Severe
- GB05  Very Severe

### WATER EROSION

- GC01  No Sheet Erosion
- GC02  Minor Sheet Erosion
- GC03  Moderate Sheet Erosion
- GC04  Severe Sheet Erosion
- GD01  No Rill Erosion
- GD02  Minor Rill Erosion
- GD03  Moderate Rill Erosion
- GD04  Severe Rill Erosion
- GE01  No Gully Erosion
- GE02  Minor Gully Erosion
- GE03  Moderate Gully Erosion
- GE04  Severe Gully Erosion

### GULLY EROSION DEPTH

- GF01  <1.5m
- GF02  1.5 - 3.0m
- GF03  >3.0m

### WATER EROSION

- GG01  No Tunnel Erosion
- GG02  Tunnel Erosion
- GH01  No Streambank Erosion
- GH02  Streambank Erosion
- GJ01  No Wave Erosion
- GJ02  Wave Erosion
- GK01  No Mass Movement
- GK02  Mass Movement
- GL01  Other Erosion

### Soil Parent Material

- IB01
- IB02
- IB03
- IB04
- IB05
- IB06
- IB07
- IB08
- IB09
- IB10
- IB11
- IB12
- IB13
- IB14
- IB15
- IB16
- IB17
- IB18
- IB19
- IB20

### LITHOLOGY

- IC01  Not Identified
- IC02  Igneous
- IC03  Serpentine
- IC04  Diorite
- IC05  Granodiorite
- IC06  Granite
- IC07  Basalt / Dolerite
- IC08  Andesite
- IC09  Trachyte / Syenite
- IC10  Rhyolite
- IC11  Sedimentary
- IC12  Conglomerate
- IC13  Sandstone
- IC14  Shale
- IC15  Mudstone / Siltstone
- IC16  Limestone
- IC17  Metamorphic
- IC18  Amphibolite / Greenstone
- IC19  Slate / Hornfels
- IC20  Schist / Phyllite
- IG01  Gneiss
- IG02  Quartzite
- IG03  Unclassified
- IG04  Gravel
- IG05  Sand
- IG06  Silt
- IG07  Clay
- IG08  Other

### Underlying Material

- IC01
- IC02
- IC03
- IC04
- IC05
- IC06
- IC07
- IC08
- IC09
- IC10
- IC11
- IC12
- IC13
- IC14
- IC15
- IC16
- IC17
- IC18
- IC19
- IC20

### TYPE OF SOIL OBSERVATION

- JAB1  Soil Pit
- JAB2  Existing Vertical Exposure
- JAB3  Soil Core
- JAB4  Auger Boring

### ADDENDUM


### DOMINANT SPECIES

BE01	<input type="checkbox"/>	
BE02	<input type="checkbox"/>	
BE03	<input type="checkbox"/>	

(EUCS - BOXS)

### LANDSURFACE

CONDITION OF SURFACE SOIL

- CA01  Periodic Cracking
- CA02  Self Mulching
- CA03  Loose
- CA04  Soft
- CA05  Firm
- CA06  Hard Setting
- CA07  Surface Crust
- CA08  Recently Cultivated
- CA09  Saline
- CA10  Other

## NOTES RECORD

Record Type  
B, B, B, 3

GOLDERS SITE 1922

---



---



---



---



---

Figure 18 Example of cross-out site description sheet — front

SITE 85 cont.

### SOIL PROFILE RECORD 'A'

Layer No.	Horizon	Lower Average Depth (m)	Dominant Colour (Munsell Code)				Mottle						pH
			Moist		Dry		Primary			Secondary			
			Abund.	Size	Contr.	Colour	Abund.	Size	Contr.	Colour	Soil Water Sat.		
1	A1	0-10	5.0YR	2/4									6.0
2	A1	10-30	2.5YR	3/3									7.0
3	B1	30-45	2.5YR	3/4									6.5
4	B2	45-60	5.0YR	4/8									6.5
5													
6													

Record Type  
g, g, d, 5

### SOIL PROFILE RECORD 'B'

**FIELD TEXTURE**

**SAND FRACTION**

MA01						Fine
MA02						Coarse

**GRADE**

MB01						Silt
MB02						Loamy Sand
MB03						Clayey Sand
MC01						Sandy Loam
MC02						Fine Sandy Loam
MC03						Light Sandy Clay
MD01						Loam
MD02						Loam, Fine Sandy
MD03						Silt Loam
MD04						Sandy Clay Loam
ME01						Clay Loam
ME02						Silty Clay Loam
ME03						Fine Sandy Clay
MF01						Sandy Clay Loam
MF02						Silty Clay
MF03						Light Clay
MF04						Light Medium Clay
MG01						Medium Clay
MG02						Heavy Clay

**COARSE FRAGMENTS**

**ABUNDANCE**

NA01						None
NA02						1-2%
NA03						2-10%
NA04						10-20%
NA05						25-50%
NA06						50-90%
NA07						>90%

**SHAPE**

NB01						Rounded
NB02						Subrounded
NB03						Subangular
NB04						Angular

**DISTRIBUTION**

NC01						Reoriented
NC02						Undisturbed
NC03						Stratified
NC04						Dispersed

**SIZE**

ND01						2-6 mm
ND02						6-20mm
ND03						20-60 mm
ND04						60-200mm
ND05						200-600mm
ND06						>600mm

**LITHOLOGY**

NE01						Quartz
NE02						Igneous
NE03						Sedimentary
NE04						Metamorphic
NE05						Same As Parent Material
NE06						Not Identified

**STRUCTURE GRADE**

PA01						Primary
PA02						Secondary
PA03						Primary
PA04						Secondary
PA05						Primary

**PANS CEMENTATION**

UA01						Uncemented
UA02						Weakly Cemented
UA03						Moderately Cemented
UA04						Strongly Cemented
UA05						Very Strongly Cemented

**PED SIZE**

PC01						Primary
PC02						Secondary
PC03						Primary
PC04						Secondary
PC05						Primary
PC06						Secondary
PC07						Primary
PC08						Secondary
PC09						Primary

**PED TYPE**

PE01						Primary
PE02						Secondary
PE03						Primary
PE04						Secondary
PE05						Primary
PE06						Secondary
PE07						Primary
PE08						Secondary
PE09						Primary

**FABRIC**

QA01						Earthy
QA02						Sandy
QA03						Smooth Ped
QA04						Rough Ped

**CUTANS**

RA01						None
RA02						Few (<10%)
RA03						Common (10-50%)
RA04						Many (>50%)

**VOIDS PORES**

SA01						Macropores
SA02						No macropores

**CRACK WIDTH**

SB01						<5mm
SB02						5-10mm
SB03						10-20mm
SB04						20-50mm
SB05						>50mm

**CONSISTENCE STRENGTH**

TA01						Loose
TA02						Very Weak
TA03						Moderately Weak
TA04						Moderately Firm
TA05						Very Firm
TA06						Moderately Strong
TA07						Very Strong
TA08						Rigid

**PLASTICITY TYPE**

TB01						Superplastic
TB02						Normal Plastic
TB03						Subplastic
TB04						Strongly Plastic

**STICKINESS**

TC01						Non Sticky
TC02						Slightly Sticky
TC03						Moderately Sticky
TC04						Very Sticky

**TYPE**

UB01						No Pans
UB02						Calcrete
UB03						Silcrete
UB04						Iron Pan
UB05						Sesquioxide Pan
UB06						Oxisol
UB07						Coffee Rock
UB08						Other

**CONTINUITY**

UC01						Continuous
UC02						Discontinuous
UC03						Broken

**SEGREGATIONS ABUNDANCE**

VA01						0
VA02						<2%
VA03						2-10%
VA04						10-20%
VA05						20-50%
VA06						>50%

**NATURE**

VB01						Calcareous
VB02						Gypsaceous
VB03						Feruginous
VB04						Manganiferous
VB05						Organic
VB06						Other

**FORM**

VC01						Nodules
VC02						Crystals
VC03						Soil Segregations

**SIZE**

VD01						<2mm
VD02						2-6mm
VD03						6-20mm
VD04						20-60mm
VD05						>60mm

**ROOTS**

WA01						None
WA02						Few
WA03						Common
WA04						Many
WA05						Abundant

**BOUNDARY DISTINCTNESS**

XA01						Sharp (<5mm)
XA02						Abrupt (5-20mm)
XA03						Clear (20-50mm)
XA04						Gradual (50-100mm)
XA05						Diffuse (>100mm)

**SHAPE**

XB01						Smooth
XB02						Wavy
XB03						Irregular
XB04						Broken

Figure 19 Example of cross-out site description sheet — reverse

# CROSS - OUT SITE DESCRIPTION SHEET HEADER RECORD

Record Type P 2 2 1		Survey Code GEO		Site 56		Great Soil Group Code N8BDC2.1		Principal Profile Form		Soil or Land Class	
Described by TRD		Photo		Reference		Date					
Film Number		Run No.		Frame No.		Exposure		North		Date	
777181691		777181691		13808		0586					
Map Sheet Number		Map Scale 1:		Map Zone		Map Reference					
853211+11		5000085		M6000000		6355800					
Slope Value		Elevation (m)		Aspect		Depth of Regolith (m)		Depth of Standing Water		Rainfall (mm)	
4.0%		29.0		-		30		3.0		552	

Record Type  
P 2 2 2

## LANDFORM, VEGETATION, LANDSURFACE, SUBSTRATE MATERIAL RECORD

### LANDFORM

- LANDFORM ELEMENT MORPHOLOGICAL TYPE
- AA01  Crest
  - AA02  Upper Slope
  - AA03  Mid-Slope
  - AA04  Lower Slope
  - AA05  Simple Slope
  - AA06  Flat
  - AA07  Open Depression
  - AA08  Closed Depression
  - AA09  Hilltop
  - AA10  Ridge

### VEGETATION

- TYPE OF FOREST
- BA01  Non-Rainforest
  - BA02  Rainforest

### STRUCTURAL FORMATION CLASS

- |      |                                     |                |
|------|-------------------------------------|----------------|
| BC01 | <input type="checkbox"/>            | Tree           |
| BC02 | <input type="checkbox"/>            | Tree Mallee    |
| BC03 | <input type="checkbox"/>            | Shrub          |
| BC04 | <input type="checkbox"/>            | Mallee shrub   |
| BC05 | <input type="checkbox"/>            | Heath Shrub    |
| BC06 | <input type="checkbox"/>            | Chenopod Shrub |
| BC07 | <input type="checkbox"/>            | Hummock Grass  |
| BC08 | <input checked="" type="checkbox"/> | Tussock Grass  |
| BC09 | <input type="checkbox"/>            | Sedge          |
| BC10 | <input type="checkbox"/>            | Rush           |

### UPPER STOREY TREE HEIGHT CLASS

- BD01  >35.01 m
- BD02  20.01 - 35m
- BD03  12.01 - 20m
- BD04  6.01 - 12m
- BD05  3.01 - 6m
- BD06  1.01 - 3m
- BD07  0.51 - 1m
- BD08  0.26 - 0.5m
- BD09  <0.25m

### DOMINANT SPECIES

- BE01
- BE02
- BE03

### LANDSURFACE

#### CONDITION OF SURFACE SOIL

- CA01  Periodic Cracking
- CA02  Self Mulching
- CA03  Loose
- CA04  Silt
- CA05  Firm
- CA06  Hard Setting
- CA07  Surface Crust
- CA08  Recently Cultivated
- CA09  Saline
- CA10  Other

### RUN-OFF

- DA01  None
- DA02  Very Slow
- DA03  Slow
- DA04  Moderately Rapid
- DA05  Rapid
- DA06  Very Rapid

### INTERNAL DRAINAGE

- PERMEABILITY
- EAB1  Slowly Permeable
  - EAB2  Moderately Permeable
  - EAB3  Highly Permeable

### DRAINAGE

- EB01  Very Poorly Drained
- EB02  Poorly Drained
- EB03  Imperfectly Drained
- EB04  Moderately Well Drained
- EB05  Well Drained
- EB06  Rapidly Drained

### ROCK OUTCROP

- FA01  None
- FA02  <10%
- FA03  10-50%
- FA04  >50%

### EROSION

#### STATE OF EROSION

- GA01  Active
- GA02  Stabilized
- GA03  Partly Stabilized

#### WIND EROSION

- GB01  None
- GB02  Minor
- GB03  Moderate
- GB04  Severe
- GB05  Very Severe

#### WATER EROSION

- GC01  No Sheet Erosion
- GC02  Minor Sheet Erosion
- GC03  Moderate Sheet Erosion
- GC04  Severe Sheet Erosion
- GD01  No Rill Erosion
- GD02  Minor Rill Erosion
- GD03  Moderate Rill Erosion
- GD04  Severe Rill Erosion
- GE01  No Gully Erosion
- GE02  Minor Gully Erosion
- GE03  Moderate Gully Erosion
- GE04  Severe Gully Erosion

#### GULLY EROSION DEPTH

- GF01  <1.5m
- GF02  1.5 - 3.0m
- GF03  >3.0m

#### WATER EROSION

- GH01  No Tunnel Erosion
- GH02  Tunnel Erosion
- GH03  No Streambank Erosion
- GH04  Streambank Erosion
- GJ01  No Wave Erosion
- GJ02  Wave Erosion
- GK01  No Mass Movement
- GK02  Mass Movement
- GL01  Other Erosion

### DISTURBANCE OF SITE

- HAB1  No Effective Disturbance (NED)
- HAB2  NED Exceed Hoofed Animals
- HAB3  Limited Clearing
- HAB4  Extensive Clearing
- HAB5  Complete Clearing, Pasture, Never Cultivated
- HAB6  Complete Clearing, Pasture, Cultivated
- HAB7  Cultivation Dryland
- HAB8  Cultivation Irrigated Past / Present
- HAB9  Highly Disturbed

### SUBSTRATE MATERIAL

#### STRENGTH

- IAG1  Very Weak
- IAG2  Weak
- IAG3  Moderate
- IAG4  Strong
- IAG5  Very Strong

#### LITHOLOGY

- | Soil Parent Material | LITHOLOGY                | Underlying Material |
|----------------------|--------------------------|---------------------|
| IB01                 | Not Identified           | IC01                |
| IB02                 | Igneous                  | IC02                |
| IB03                 | Serpentine               | IC03                |
| IB04                 | Diorite                  | IC04                |
| IB05                 | Granodiorite             | IC05                |
| IB06                 | Gneiss                   | IC06                |
| IB07                 | Basalt / Gabbro          | IC07                |
| IB08                 | Andesite                 | IC08                |
| IB09                 | Trachyte / Syenite       | IC09                |
| IB10                 | Rhyolite                 | IC10                |
| IO01                 | Sedimentary              | IE01                |
| IO02                 | Conglomerate             | IE02                |
| IO03                 | Sandstone                | IE03                |
| IO04                 | Shale                    | IE04                |
| IO05                 | Mudstone / Siltstone     | IE05                |
| IO06                 | Limestone                | IE06                |
| IF01                 | Metamorphic              | IG01                |
| IF02                 | Amphibolite / Greenslate | IG02                |
| IF03                 | Slate / Hornfels         | IG03                |
| IF04                 | Schist / Phyllite        | IG04                |
| IF05                 | Gneiss                   | IG05                |
| IF06                 | Quartzite                | IG06                |
| IH01                 | Unconsolidated           | IJ01                |
| IH02                 | Gravel                   | IJ02                |
| IH03                 | Sand                     | IJ03                |
| IH04                 | Silt                     | IJ04                |
| IH05                 | Clay                     | IJ05                |
| IJ01                 | Other                    | IK01                |

#### TYPE OF SOIL OBSERVATION

- JAB1  Soil Pit
- JAB2  Exposing Vertical Exposure
- JAB3  Soil Core
- JAB4  Auger Boring

#### ADDENDUM


Record Type  
P 2 2 3

## NOTES RECORD

GOLDBERG SITE TP13. TAILINGS DAM AREA	

Figure 18 Example of cross-out site description sheet — front

SITE 86 cont.

### SOIL PROFILE RECORD 'A'

Layer No.	Horizon	Lower Average Depth (m)	Dominant Colour (Munsell Code)					Mottles					pH	
			Moist		Dry			Primary			Secondary			Soil Water Sat.
			Moist	Dry	Abund.	Size	Contr.	Colour	Abund.	Size	Contr.	Colour		
1	A1	1.0	5.0YR	3.6									5.0	
2	B2	3.0	2.5YR	3.3									6.0	
3														
4														
5														
6														

Record Type  
B U B 5

### SOIL PROFILE RECORD 'B'

#### FIELD TEXTURE

##### SAND FRACTION

	1	2	3	4	5	6
MA#1						
MA#2						

##### GRADE

	1	2	3	4	5	6
MB#1						
MB#2						
MB#3						
MC#1						
MC#2						
MC#3						
MD#1						
MD#2						
MD#3						
MD#4						
ME#1						
ME#2						
ME#3						
ME#4						
ME#5						
ME#6						
MF#1						
MF#2						
MF#3						
MF#4						
MG#1						
MG#2						

#### COARSE FRAGMENTS

##### ABUNDANCE

	1	2	3	4	5	6
NA#1						
NA#2						
NA#3						
NA#4						
NA#5						
NA#6						
NA#7						

##### SHAPE

	1	2	3	4	5	6
NR#1						
NR#2						
NR#3						
NR#4						

##### DISTRIBUTION

	1	2	3	4	5	6
NC#1						
NC#2						
NC#3						
NC#4						

##### SIZE

	1	2	3	4	5	6
ND#1						
ND#2						
ND#3						
ND#4						
ND#5						
ND#6						

##### LITHOLOGY

	1	2	3	4	5	6
NE#1						
NE#2						
NE#3						
NE#4						
NE#5						
NE#6						

#### STRUCTURE

##### GRADE

	1	2	3	4	5	6
PA#1						
PA#2						
PA#3						
PA#4						
PA#5						

##### PED SIZE

	1	2	3	4	5	6
PC#1						
PC#2						
PC#3						
PC#4						
PC#5						
PC#6						
PC#7						
PC#8						
PC#9						

##### PED TYPE

	1	2	3	4	5	6
PE#1						
PE#2						
PE#3						
PE#4						
PE#5						
PE#6						
PE#7						
PE#8						
PE#9						

##### FABRIC

	1	2	3	4	5	6
QA#1						
QA#2						
QA#3						
QA#4						

##### CUTANS

	1	2	3	4	5	6
RA#1						
RA#2						
RA#3						
RA#4						

##### VOIDS

	1	2	3	4	5	6
SA#1						
SA#2						

##### CRACK WIDTH

	1	2	3	4	5	6
SB#1						
SB#2						
SB#3						
SB#4						
SB#5						

##### CONSISTENCE

	1	2	3	4	5	6
TA#1						
TA#2						
TA#3						
TA#4						
TA#5						
TA#6						
TA#7						
TA#8						

##### PLASTICITY TYPE

	1	2	3	4	5	6
TB#1						
TB#2						
TB#3						
TB#4						

##### STICKINESS

	1	2	3	4	5	6
TC#1						
TC#2						
TC#3						
TC#4						

#### PANS

##### CEMENTATION

	1	2	3	4	5	6
UA#1						
UA#2						
UA#3						
UA#4						
UA#5						

##### TYPE

	1	2	3	4	5	6
UB#1						
UB#2						
UB#3						
UB#4						
UB#5						
UB#6						
UB#7						
UB#8						

##### CONTINUITY

	1	2	3	4	5	6
UC#1						
UC#2						
UC#3						

##### SEGREGATIONS

##### ABUNDANCE

	1	2	3	4	5	6
VA#1						
VA#2						
VA#3						
VA#4						
VA#5						
VA#6						

##### NATURE

	1	2	3	4	5	6
VB#1						
VB#2						
VB#3						
VB#4						
VB#5						
VB#6						

##### FORM

	1	2	3	4	5	6
VC#1						
VC#2						
VC#3						

##### SIZE

	1	2	3	4	5	6
VD#1						
VD#2						
VD#3						
VD#4						
VD#5						

##### ROOTS

	1	2	3	4	5	6
WA#1						
WA#2						
WA#3						
WA#4						
WA#5						

##### BOUNDARY

##### DISTINCTNESS

	1	2	3	4	5	6
XA#1						
XA#2						
XA#3						
XA#4						
XA#5						

##### SHAPE

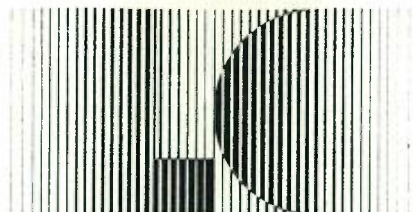
	1	2	3	4	5	6
XB#1						
XB#2						
XB#3						
XB#4						

Figure 19 Example of cross-out site description sheet — reverse

**APPENDIX H**

**NOISE INVESTIGATION**

Louis A. Challis & Associates Pty. Ltd.



**Challis and Associates Pty Limited**  
Consulting Acoustical and Vibration Engineers

246-248 Dowling Street  
Kings Cross Sydney  
2011 Australia  
Telephone (02) 357 1866  
Telegraphic Code "Acoustic"  
PO Box 199 Kings Cross  
Fax. (02) 357 3684

Directors  
L A Challis *BE MSc (Arch)*  
*FIE (Aust) FRSA*  
A M Challis  
*Bsc MSc (Arch) SEG ASEG*

REPORT NO. 5204-3-88

ACOUSTICAL ASSESSMENT OF  
PROPOSED GOONUMBLA GOLD MINING PROJECT  
PARKES, NEW SOUTH WALES

Prepared for :

Natural Systems Research Pty. Ltd.  
Brascon House  
25 Burwood Road  
HAWTHORN VIC 3122

On behalf of :

Peko Wallsend Limited  
Metalliferous Mining Division  
25 Merriwa Street  
GORDON NSW 2072

15th December 1988



## C O N T E N T S

### PAGE NO.

1.	INTRODUCTION	1
2.	DESCRIPTION OF AREA	1
2.1	Nature of the Development	1
2.2	Relationship to Adjacent Properties	3
3.	EXISTING ACOUSTICAL ENVIRONMENT	3
3.1	Measurement of Existing Ambient Sound Levels	3
3.2	Sound Propagation Measurements	5
4.	CRITERIA FOR COMMUNITY NOISE ASSESSMENT	8
4.1	General	8
4.2	Statistical Assessment of Community Noise Levels	8
4.3	State Pollution Control Commission Background Level Criteria	9
4.4	SPCC Planning Criteria for New Industrial Developments	10
5.	ASSESSMENT OF MINING NOISE	11
5.1	Individual Source Sound Power Emission	11
5.2	Base Data for Computer Modelling	12
6.	COMMENTS ON THE RESULTS	13
6.1	Potential Noise Impact	13
6.2	Future Property Acquisitions	14
6.3	Supplementary Plant Noise Control	14
6.4	Architectural Acoustical Treatment	15
6.5	Potential Noise Impact	15
7.	ASSESSMENT OF TRANSPORTATION NOISE	16
7.1	Road Transportation	16
7.2	Rail Loading	18
8.	CONCLUSIONS	20

### TABLES

I	Summary of Existing Ambient Sound Levels	5
II	Octave Band Sound Power Levels of Individual Sources	11
III	Source Powers and Positions Adopted for Computer Model	12
IV	Properties Listed for Tentative Acquisition	14
V	Predicted Sound Levels at Nearest Residential Properties	15
VI	Predicted Noise Levels of Daytime Trucking Operations	17
VII	Base Sound Levels of Proposed Rail Loading Operations	19

### FIGURE

1	Site Plan Showing Measurement Positions
2	Site Plan Showing Location of Noise-Affected Residences

### APPENDICES

1	Details of Measurement Equipment
2	Existing Ambient Sound Levels
3	Results of Sound Propagation Measurements

## 1. INTRODUCTION

This report presents the results of an acoustical investigation carried out during the period June 1986 to October 1988 to assess the potential acoustical impact of the Goonumbla gold mine project at Parkes, New South Wales.

The studies have involved an assessment of the existing ambient sound levels and sound propagation characteristics of the area, together with a computer modelling study to assess potential acoustical impact at the adjacent residential properties.

The study assesses the relevant acoustical criteria for mining operations in the area on the basis of existing environmental noise levels and relates the criteria to environmental noise emission requirements nominated by the New South Wales State Pollution Control Commission. Noise predictions for future mining operations have been undertaken, based on the proposed mining equipment, its working locations and the measured sound propagation data previously determined.

Residences likely to be adversely affected by noise are identified, and the potential amelioration measures assessed on the basis of practicality and relevance.

The impact of off site transportation noise is also assessed at the two residential properties adjacent to the Goonumbla siding.

## 2. DESCRIPTION OF THE AREA

### 2.1 Nature of the Development

The Goonumbla Project is situated approximately 30km north of Parkes, NSW, in what is currently a relatively quiet rural area. The future development of the gold mine will be based on three open pits which have been designated as E26N, E22 and E27 which are shown schematically in relation to the nearest farm properties and residences in Figure 2. The mining development is based on the location of the crushing and ore treatment plant immediately to the south of E27.

The E22 and E27 pits would then be connected to the crushing plant by means of haul roads. The crushing and processing plant would be subsequently connected by means of a haul road to the E26N pit approximately two years after the commencement of mining operations.

The primary initial noise generation activities will be those associated with the removal of topsoil by scrapers; the subsequent removal of the weathered rock by excavators and trucks; and finally the noise generation activities associated with drilling and blasting the hard rock to provide access to the bedrock containing the gold bearing ore.

This ore, together with the waste material will be removed by large haul trucks which will be loaded with ore and spoil with large front-end loaders. The hard waste material will be carefully dumped around three sides of each of the pits to form elevated rock berms to minimise the propagation of noise emission in the directions of the nearest residential properties. Additional unprocessed waste material, as well as the ore required for processing, will be stored in elevated 20 metre high stock piles beside the E22 and E27 pits, with additional stock piles numbered 3 to 6 being located immediately to the south of the E27 pit, flanking the primary haul road serving the primary stock pile conveyor system. The ore will be fed from the point where it is dumped at the primary feed chute onto a primary stock pile, from where it will be transported by conveyor to the first of a number of stages of crushing and grinding. The processing plant will be enclosed by a building which provides both weather protection and limited noise attenuation. The hauling of ore to the primary dumping station and the primary crushing of the ore will take place on a three shift basis from Mondays through to Fridays.

The plant area facilities will consist of a dump station, primary crusher with subsequent conveyors feeding the ore and waste material through additional stages of crushing, grinding, concentration and ore collection. The concentrator will house secondary and tertiary cone crushers, ball mills, rod mills, screens and the necessary flotation modules in a sheeted steel building which will be clad down to a point approximately 5m above ground level.

The ore processing plant will operate on a three-shift basis, seven days per week.

## 2.2 Relationship to Adjacent Properties

There are 21 residential properties within approximately 5km radius of the nearest of the open pits (Figure 1). The company has stated its intention to acquire the following properties:

"Orana", "Estcourt", "Bonni Doon", "Pinegrove", "Bradeside", "Rosedale", "Altona", "Rocklands", and "Hopetoun".

In addition serious consideration will be given to either acquiring or acoustically treating each of the following properties:

"Adavale", "Beechmore" (whose position we cannot identify), "Fernleigh", "Milpose", "Avondale", "Kundibah" and "The Overalls".

Of the above properties, "Altona", "Braeside", "Rocklands" and "Pinegrove" are located in areas that will be required for mining and related activities, and consequently do not constitute residential properties requiring further consideration in this study.

An evaluation of the topography of the site reveals that it is generally flat, providing minimal potential natural screening from the mine site. Our site inspections did indicate a possible local screening effect between the E26N pit area and the "Hopetown" and "Milpose" homesteads to the south and south-west, respectively.

## 3. EXISTING ACOUSTICAL ENVIRONMENT

### 3.1 Measurement of Existing Ambient Sound Levels

Measurements of existing ambient sound levels were made at four (4) locations over the period 10th to 13th June 1986 at the following positions:

- |            |                                   |
|------------|-----------------------------------|
| Position 1 | Entrance to "Hopetown" property.  |
| Position 2 | Entrance to "Beechmore" property. |

- Position 3      Outside "Orana" homestead adjacent to shed at rear of house.  
Position 4      Outside "Bonnie Doon" homestead adjacent to shed at side of house.

The measurements at Positions 1 and 2 were conducted in the form of statistical noise samples over a 20-minute duration, each position being sampled several times during the daytime and evening. At Positions 3 and 4, 160-minute unattended statistical samples were taken during the day and night at Position 4 and during the night only at Position 3.

The results of our acoustical assessments were recorded in the form of A-weighted percentile noise levels, with simultaneous graphic level recordings for the time history of the results (at Position 3 only) to illustrate the sound levels of individual events. The percentile noise level is defined as the noise level exceeded for a given percentage of the sample period, eg.  $L_{A10}$  is the level exceeded for 10% of the sample period and is commonly influenced by passing traffic when near a main road;  $L_{A90}$  is the level exceeded for 90% of the sample period and is commonly referred to as the background sound level;  $L_{Aeq}$  is the equivalent continuous (constant) sound level.

Weather conditions during the period of the measurements were fine with wind gusting infrequently to peak velocities of approximately 15km/hr during the day and reverting to calm conditions at night.

Details of the measurement equipment are presented in Appendix No. 3.

The results of the measurements are presented in Appendix No. 2. The statistical assessment of A-weighted sound levels results confirm that the area is generally quiet with characteristics which would be defined as an R1 zone by the State Pollution Control Commission. The area is rural with minimal vehicular traffic or other activities, apart from local noise. The results are summarised in Table 1 in terms of the existing daytime and night-time  $L_{A10}$ ,  $L_{A90}$  and  $L_{Aeq}$  levels at the measurement locations.

TABLE 1SUMMARY OF EXISTING AMBIENT SOUND LEVELS

Position	Sound Pressure Level - dB(A) re 20 micropascals		
	L <sub>A10</sub>	L <sub>A90</sub>	L <sub>Aeq</sub>
1 Entrance to "Hopetown"			
- daytime	30-39	27-29	29-47
- night-time	28-38	27	27-40
2 Entrance to "Beechmore"			
- daytime	39-46	31-32	36-42
- night-time	29	27	28
3 Outside "Orana"			
- night time	28-35	27	30-35
4 Outside "Bonnie Doon"			
- daytime	42-54	27-30	46-51
- night-time	29	27	28-32

Whilst the minimum recorded sound levels lying in the range 27-28 dB(A) are just above the internal 'noise floor' of the measurement system, they are sufficiently accurate to typify the minimum background sound levels at each of the properties.

It is relevant to note that while the ambient sound levels during the measurement period were very low, there are periods of considerably higher ambient noise levels which regularly occur during the ploughing and harvesting seasons and as a result of early morning overflights by commercial and crop dusting aircraft.

### 3.2 Sound Propagation Measurements

A series of sound propagation measurements was conducted at the proposed mine site, in order to identify whether sound propagation characteristics were likely to be either enhanced or degraded, by the topography and meteorological conditions, when compared with theoretical predictions.

Band filtered pink noise was electronically generated utilising an amplified high intensity sound source at two positions on the site designated as S1 and S2. These sites represent the nearest point of mining activity to the various homesteads. These source and the associated measurement positions are shown in Appendix 1.2.

A series of sound level were conducted at a series of intermediate positions lying between the electronic generator and the adjacent homestead at representative positions. These attenuation/propagation measurements were conducted with sound generated in the octave bands centred on frequencies lying between 125 Hz to 4 kHz.

In order to assess the influence of background noise levels on the measurements, the noise source was cyclically switched on and off during the measurements. The predominant environmental conditions of temperature, relative humidity, and the wind speed and its direction, were simultaneously monitored during the measurements. These were conducted under different conditions ranging from typical daytime propagation (with significant positive temperature gradient) to moderate and strong temperature inversion conditions at night with negative temperature gradient.

Details of the measurement equipment are presented in Appendix No. 4.

The results of the sound propagation measurements are presented in graphical form in Appendix No.5. The sound propagation graphs show the relevant sound propagation data in terms of the sound pressure level ( $L_p$ ) to sound power ( $L_w$ ) conversion relationship for variable distance. The theoretical attenuation relationship (for distance only) is shown as a straight line which decreases at 6 dB per doubling of distance. The measured octave band attenuation values are presented for the spacings (distances) at which they were evaluated.

Where the measured values of attenuation have values which are higher than the theoretical attenuation anticipated for that distance, there is an "excess attenuation" of sound. The measured sound level is less than would be theoretically predicted value.

Conversely where the measured values are above the "distance attenuation" line, there is an enhancement of propagation, resulting in an increase in the received level compared with a theoretical prediction.

The results of our measurements revealed that the "worst case" propagation occurred in the early morning of 12th June 1986 under strong temperature inversion conditions, with negligible wind with ambient temperatures close to zero. Under these conditions, it was found that the propagation characteristics generally followed the theoretical model out to a distance of approximately 1km from the source, experienced preferential propagation over the range 1.5-2.5km with an approximate peak of the order of about 5dB above the theoretical model at 2km, before dropping below the theoretical model at 3km. Under the windless conditions prevailing on that night, there appeared to be no significant directional sound propagation characteristics.

The frequencies which experienced the greatest impact as a result of the prevailing inversion conditions were those lying between 125Hz to 1kHz. At higher frequencies, the inversion characteristics appeared to have little effect and there was a measurable and significant excess attenuation. We have attributed these effects to a combination of ground and air absorption.

Under the weaker temperature inversion conditions which were measured on the evening of the 10th June 1986 and the on the morning of 13th June 1986, the propagation condition and associated attenuation were generally just below those conforming to the 'theoretical model' up to distances of 2km, but well below those conditions at 3km. There appeared to be no significant directional effects under the calm night time conditions.

The propagation and attenuation measurements conducted during daytime were limited to distances of up to 900m. These measurements were limited by the combined effects of higher background noise and the simultaneous effect of positive temperature gradient or prevailing wind velocity which act as an inhibition to sound propagation during the day.

The results in Appendix No. 5.4 indicate that in the presence of a cross wind, there was significant excess attenuation, of the order of 15-20 dB, at a distance of 500 m from the source. This increased attenuation can be primarily attributed to ground absorption, which is most significant in the 250 Hz to 1 kHz range. With the measurement position 900 m downwind, the excess attenuation was still of the order of 15 dB at 250 Hz and 500 Hz, but was reduced to about 7 dB at 1 kHz and 2 kHz. The reduction in excess attenuation at 1 kHz and 2 kHz may be attributed to wind related factors, whilst the significant excess attenuation at 250 Hz and 500 Hz is due primarily to ground absorption.

The presence of a low rise in the topography between source and receiver at this location provided a modest barrier attenuation. Under equivalent 'open ground' conditions, it is expected that the opposing effects of a 'following wind' and ground absorption, would approximately cancel each other.

#### 4. CRITERIA FOR COMMUNITY NOISE ASSESSMENT

##### 4.1 General

The assessment of community noise as a definitive technical procedure has attracted considerable attention over the last twenty years. During the last few years, the methodology for community noise assessment has significantly changed from the simple procedures which were based on assessing a sound level meter at a single point of time, to a more appropriate and accurate procedure which is based on the statistical assessment of A-weighted sound levels.

##### 4.2 Statistical Assessment of Community Noise Levels

Because environmental sound in a rural or urban environment is a time varying phenomena in which the expected range of sound levels vary by as much as 50 or more decibels as a result of passing cars, tractors, overflying planes and other transportation related sources the preferred, and now generally accepted method of recording and presenting the measurement results, is in the form of statistical parameters.

These parameters are normally defined in terms of the percentile A-weighted sound levels where the most important parameters are the  $L_1$ ,  $L_{10}$ ,  $L_{eq}$  and  $L_{90}$  levels. The  $L_1$  is defined as the sound level exceeded for 1% of the time, the  $L_{10}$  is defined as the sound level exceeded for 10% of the time, the  $L_{eq}$  is the energy equivalent level which would produce the same cumulative noise impact if averaged over the sample time period and the  $L_{90}$  level is defined as the sound level which is exceeded for 90% of the time. The  $L_1$  is generally treated as being the maximum noise level, the  $L_{10}$  level is often described as the mean peak level and the  $L_{90}$  level is often described as the mean minima or background sound level.

These recorded statistical data are conveniently presented on a statistical graph sheet (see Appendices Nos 2.1.1 to 2.4.2) on which the individual sets of statistical data may be simultaneously presented for inter-comparison purposes.

If the time history of background sound levels have also been recorded these may be conveniently presented on the same format sheets to assist in the visual assessment of the environmental noise at the relevant time and/or place (see Appendix 2.3).

#### 4.3 State Pollution Control Commission Background Level Criteria

The State Pollution Control Commission has published a set of criteria in Section 21-1 of its Environmental Noise Control Manual which present recommended outdoor background noise levels in terms of acceptable and extreme limit background noise levels ( $L_{A90}$ ). The residential areas adjacent to this development would be classified as falling under Row (a) Rural with an R1 designation in accordance with AS1055-1973. The SPCC classifies such areas as have a daytime level ranging between 45 and 50dB(A) and a night-time level (after 10.00 pm at night) as falling between 35 to 40dB(A). These criteria levels are appropriate in this situation as a basis for both design and assessment.

#### 4.4 SPCC Planning Criteria for New Industrial Developments

Acoustical criteria which would be applied by the State Pollution Control Commission (SPCC) in assessing the new Goonumbla mining project are presented in Section (20-1 to 20-6) of the SPCC "Environmental Noise Control Manual", 1985. This section of the document specifies the following design criteria:

- (i) If the existing background noise level is below 30 dB(A), the figure of 30 dB(A) should be assumed to be the background level (Page 20-2)
- (ii) The principle is to work to a level of existing "background + 5 dB(A)", but this should not result in the acceptable background sound levels specified in Section 4.2 being exceeded.

The document also points out that where the Acceptable Limit is not achievable (for technical or economic reasons), then the lowest level achievable may be adopted if the resultant noise levels at the receptor do not exceed the relevant recommended Extreme Limit. In such a case, the Company would need to show conclusively that all other alternatives were either technically or economically unfeasible.

The short term background sound levels were found to be less than 30 dB(A) during our investigations. As a consequence, the night time criterion which would apply for the development would be  $L_{A10} = 30 \text{ dB(A)} + 5 \text{ dB(A)} = 35 \text{ dB(A)}$ , which conforms to the Acceptable Limit specified in Section (21-1). (Note:  $L_{A10}$  is the A-weighted sound pressure level exceeded for 10% of the time.)

Our previous studies and experience in such matters (See Appendix No.6 - copy of paper "Provisional Night Time Criteria for Rating the Acceptability of Community Noise" Challis, Louis A., Internoise 82), a noise level criterion of 35 dB(A) for night-time operations is appropriate in a very quiet rural area such as in the present study, where there is no other activity of a similar nature to that proposed already taking place.

The daytime background noise levels typically ranged between 27 and 32 dB(A) consequently, the daytime criterion which would apply is that nominated by the SPCC in Section 21-1 which is 45 dB(A). This level conforms to our criteria of normal acceptability for background sound levels in rural or urban areas.

## 5. ASSESSMENT OF MINING NOISE

### 5.1 Individual Source Sound Power Emission

A computerised prediction of mining noise impact was carried out utilising the following source data and numbers of equipment as presented in Table II below:

TABLE II

Octave Band Sound Power Levels of Individual Sources

	Sound Power Level dB re 10 <sup>-12</sup> Watts									
	Octave Band Centre Frequency (Hz)									
	32	63	125	250	500	1K	2k	4k	8k	A
Prestrip Drill (2)	107	119	123	120	116	116	117	121	116	125
85 Tonne Haul Truck (14)	111	126	119	119	117	118	114	109	98	122
D8 Dozer (3)	100	106	113	106	112	110	106	101	94	114
Stockpile Conveyor (2)	-	113	104	100	102	96	89	83	77	102
Grader at Tailings Dam (1)	98	105	115	109	111	118	119	102	94	122
Gyratory Crusher (1)	105	109	107	109	108	108	106	99		
Apron Feeder (1)	95	87	101	102	105	108	107	103	96	
Jaw Crusher Partially										
Enclosed	96	102	114	121	125	127	122	113	101	132
Vibratory Feeder (1)	125	115	105	107	105	105	107	110	108	113
Screen		108	112	110	112	111	111	109	100	116
Hydracone Crusher	105	109	107	109	108	108	106	99	-	113
Rodmill + Ballmill		108	113	110	113	114	112	108	103	118

## 5.2. Base Data for Computer Modelling

In order to assess the first stage development of the project the relevant section of Geop-Peko Map 8532-111-SW was utilised as the basis for the grid model. Point No.1 was located at a point corresponding to grid line 206000 as the western boundary, whilst grid line 218000 was selected as the eastern most boundary of the noise map. Grid line 1361000 was taken as the northern most point on the Geo-Peko Map and grid line 1347000 was taken as the southern most grid line on the contour map.

The sources incorporated in this model were assumed to be operating in the pit, on the overburden dumps adjacent to the pits and on the road leading up to ore crushing and processing plant.

The data on which the computer model (Table III below) has been based:

TABLE III

Source Powers and Positions Adopted for Computer Model

Octave Band Centre Frequency (Hz)	Grid	Sound Power re dB re 10 <sup>-12</sup> watts								
		32	63	125	250	500	1k	2k	4k	8k
Source 1 Drill	(20.17)	107	199	123	120	116	116	117	121	116
Source 2 Drill	(16.18)	107	199	123	120	116	116	117	121	116
Source 3 Truck	(17.19)	111	126	119	119	117	118	114	109	98
Source 4A Truck	(18.19)	111	126	119	119	117	118	114	109	98
Source 4B Truck	(18.19)	111	126	119	119	117	118	114	109	98
Source 5A Truck	(19.19)	111	126	119	119	117	118	114	109	98
Source 5B Truck	(19.19)	111	126	119	119	117	118	114	109	98
Source 6 Truck	(21.20)	111	126	119	119	117	118	114	109	98
Source 7 Truck	(22.21)	111	126	119	119	117	118	114	109	98
Source 8 Cat D8	(19.18)	100	106	113	106	112	110	106	101	94
Source 9 Cat D8	(18.18)	100	106	113	106	112	110	106	101	94
Source 10 Conveyor & Feeder	(23.22)	100	116	108	105	108	109	107	103	96
Source 11 Plant	(24.22)	132	121	119	122	126	127	122	115	110
Grader at Tailings Dam		98	105	115	109	111	118	119	102	94

These sources have formed the basis for the computerised analysis, copies of which are appended (Appendix No. 4.1 and 4.2).

6. COMMENTS ON THE RESULTS

6.1 Potential Noise Impact

The most significant source of potential noise impact will be the mine haul trucks whose individual sound power, in the critical octave band centred on 63, 125 and 250 Hz, is only exceeded by that produced by the pre-strip drills and the partially enclosed jaw crusher. There will be approximately 14 haul trucks, at least half of which are likely to be moving at any one time during the day time, and at least one third at night, in situations which are either unscreened, or partially screened. The pre-strip drills are likely to be partially screened, whilst the jaw crusher will be partially enclosed and capable of being screened, should this be required. Because of the relatively large numbers of haul trucks, their degree of exposure and their mobility, their noise emission becomes far more significant than had been previously apparent. In view of this, their specification and procurement requirements assumes major importance. It is our recommendation that each of these haul trucks be procured with O.E.M. 'hush kits' which ensure the lowest possible noise emission, and most critically the lowest possible engine exhaust noise emission, through the application of a more effective (supplementary) silencing system.

On the basis that such systems can only achieve a 4-5 dB(A) noise reduction in the critical octave bands centred on 63-250 Hz, it will not prove feasible to achieve daytime and nighttime noise levels which conform to the criteria specified in section 4.4 above. This will result in noise levels at those properties which the company does not intend to acquire which are equal to or greater than 45 dB(A), and potential night time noise levels which would lie between 40 and 45 dB(A) (depending on meteorological conditions).

## 6.2 Future Property Acquisitions

Table IV contains the list of properties in the original Goonumbla Project Review of Environmental Factors - Summary (page 19), which were subject to tentative acquisition:

TABLE IV

Properties Listed for Tentative Acquisition  
In Original Project Review of Environmental Factors

Bonnie Doon,  
Estcourt  
Orana  
Altona  
Hopetoun  
Rocklands  
Pinegrove  
Braeside  
Rosedale

Our initial computer analysis confirms that all of the above listed properties fall within the 45 dB(A)\* contour, and their acquisition would thus appear to be fully justified.

\* This contour value would be likely to be 50 dB(A) if haul trucks without hush kits were to be utilised.

## 6.3 Supplementary Plant Noise Control

Our initial assessment of the ranking of the potential sound powers and associated significance of each of the major plant items confirmst that the dominant noise source in terms of potential community impact will be the 85 tonne haul trucks. Because these sources are multiple, mobile and they effectively outrank all other noise sources, including the processing plant, they will require more attention in terms of their acoustical procurement requirements, mode of operation and we believe also in terms of their operating times. As appropriate levels of attenuation cannot be applied through either the procurement and/or operation of the haul trucks, then architectural acoustical treatment of the nearest, and otherwise affected residences, becomes mandatory.

#### 6.4 Architectural Acoustical Treatment

As it appears that engineering noise control of haul trucks is impeded as a result of the Company's inability to purchase suitably silenced equipment, then the application of architectural acoustical treatment of individual properties becomes the preferred option. This will involve the provision of special glazing, supplementary ventilation and/or airconditioning together with modification of those sections of the residences building envelope where potential a night time acoustical impact is anticipated. Those rooms which are likely to require such special architectural treatment are the bedrooms, and in special circumstances, the living room.

Although the residences concerned have not been inspected at this point of time, the existing building transmission losses are anticipated to lie in the range 15-24 STC, whilst the potential attenuation to be provided is likely to lie in the range 30-35 STC, the precise value depending on the location of the residence and the orientation and position of the bedrooms within each of those residences.

#### 6.5 Potential Noise Impact

Table V presents a tabulation of potential noise impact at the nearest residential properties for Stage I development.

TABLE V

Predicted Sound Levels at Nearest Residential Properties

Residence	Predicted Sound Level - $L_{A10}$ - dB(A)		
	Night-time With Normal Haul Trucks	Night-time With Silenced Haul Trucks	Daytime With Normal Haul Trucks
"Beechmore"	50	46	47
"Fernleigh"	43	40	40
"Milpose"	45	41	42
"Hopetown"	46	41	42
"Hill View"	45	40	41
"Avondale"	50	45	45
"Kundibah"	49	44	44
"Orana"	50	45	45
"Rosedale"	65	63	63
"Estcourt"	60	56	57
"Adavale"	48	44	45

The computed sound levels represent a "worst case" analysis with either zero wind, or a light wind with velocity in the range 2-5/km per hour blowing towards any particular residence during the day.

The likely frequency of these unfavourable conditions can be expected to be less than 10% of the time in a given year.

## 7. ASSESSMENT OF TRANSPORTATION NOISE

### 7.1 Road Transportation

It is currently proposed to truck the product from the mine site to a new rail siding to be constructed approximately 1km north of the Goonumbla village on the Parkes-Narromine Railway. The nearest residences to the trucking route would be as follows:

- \* "Hill View" - presently unoccupied, approximately 350m from the Goonumbla road.
- \* "Berra Lea" - presently occupied, approximately 200m from the Goonumbla road.
- \* Goonumbla village - two houses presently occupied, each set back approximately 10-15m from the Goonumbla road.

Trucking would take place on a daytime basis for five days per week, at a rate of approximately 5 semi-trailers per day during phase I and 15 semi-trailers per day during phase II. Supplementary truck movements associated with the delivery of consumables would be unlikely to exceed 5 trucks per day.

The most appropriate descriptor for truck noise with small numbers of movements would be in terms of either the  $L_{A10}$  level or in terms of the  $L_{Aeq}$  level.

An appropriate criterion for daytime operations in a rural area would thus be as follows:

$$L_{A10} = 55 \text{ dB(A)}$$

$$L_{Aeq} = 45 \text{ dB(A)}$$

Based on our noise level assessments for trucks at various distances, the following predictive relationship has been established:

$$L_{Aeq} = 50 - 15 \log \frac{d}{10} + 10 \log 2N, \quad \text{dB}$$

where  $d$  = distance in metres

$N$  = number of trucks per hour, ie. 3

This predictive relationship is determined on the basis of the maximum sound level of the truck not exceeding 89 dB(A) when tested according to the standard "blip" test. This test consists of a measurement of the maximum A-weighted sound level at 1m from the truck exhaust, with the engine being revved rapidly to maximum speed then being allowed to decelerate. The predictive relationship also takes into account the higher noise levels typically generated as a result of the "bouncing" of the empty truck tray. The above sound levels represent typical truck noise levels which are readily achievable commercially.

The predictive relationship also assumes that any excess attenuation due to ground absorption would be offset with a light wind blowing from the road towards the residences, and as such represents a typical "worst case".

The predicted noise levels at the nearest residences are presented in Table VI.

TABLE VI

Predicted Noise Levels of Daytime Trucking Operations

Residence	$L_{Aeq}$ - dB(A)
"Hill View"	35
"Berra Lea"	38
Goonumbla village	45

The predicted sound levels at "Hill View" and "Berra Lea" are in compliance with the  $L_{Aeq} = 45$  dB(A) criterion level. The predicted sound levels in the Goonumbla village would exceed the criterion level by approximately 1 dB(A). Whilst there is other sporadic activity in this area related to existing traffic on the Goonumbla road, quarrying operations nearby and seasonal wheat trucking, it is considered that the predicted level is appropriate for the discontinuous trucking operations in this area.

## 7.2 Rail Loading

The proposed rail loading operations would consist of two (2) Clark fork-lifts or equivalent, unloading empty containers from a unit train and loading full containers from a storage pad onto the train. This operation would be likely to take place over a four-hour period, which may occur at any time of the day or night. It is estimated that, at full production, up to two (2) trains per week would be loaded.

The nearest residences would be the two residences in the Goonumbla village, approximately 1km from the proposed siding, as discussed above.

Acoustical criteria for night-time operations, based on sleep disturbance criteria determined by Vallet et al<sup>2</sup>, for traffic noise, when measured inside the bedroom, are as follows:

$$\begin{aligned}L_{Amax} &= 45 \text{ dB(A)} \\L_{Aeq} &= 37 \text{ dB(A)}\end{aligned}$$

On the basis of noise isolation measurements, which we have conducted inside and outside typical rural homesteads with windows open, these criteria may be expressed in terms of external noise levels as follows:

$$\begin{aligned}L_{Amax} &= 52 \text{ dB(A)} \\L_{Aeq} &= 44 \text{ dB(A)}\end{aligned}$$

Whilst it is acknowledged that these criteria have been developed for traffic noise in urban areas, they are also considered to be generally applicable to the type of operation proposed in this instance.

Base sound levels of the proposed operations have been determined by measurements we have carried out previously, adjacent to rail loading and container facilities. These are presented in Table VII

TABLE VIIBase Sound Levels of Proposed Rail Loading Operations

Source	Sound Level at 60m - dB(A)	
	$L_{Amax}$	$L_{Aeq4}^*$
Fork-lifts (2)	63	55
Train arriving	80	53
Train waiting/loading	73	61
Train departing	<u>81</u>	<u>53</u>
TOTAL	81	63

Note \*  $L_{Aeq4}$  is the four-hour  $L_{Aeq}$  level over a typical loading period.

The predicted sound levels at the Goonumbra village, based on attenuation with distance, together with a 1 dB(A) enhancement of propagation under temperature inversion conditions (see Section 3 above), are as follows:

$$\begin{aligned} L_{Amax} &= 58 \text{ dB(A)} \\ L_{Aeq} &= 40 \text{ dB(A)} \end{aligned}$$

The predicted maximum level of 58 dB(A), which is associated with train arrivals and departures, is 6 dB(A) in excess of the peak noise emission criteria that we would normally recommend for other noise sources. It must be recognised however that this "worst case" situation is only likely to occur at most twice a week, and then only if loading occurs at night-time with simultaneous temperature inversion conditions, such as would prevail in the early morning during winter months. Under "normal" conditions for sound propagation, the sound levels of loading operations are likely to comply with the above criteria.

We would strongly recommend that:

- (i) The siding should be located as far as possible to the north of the Goonumbla village.
- (ii) The sound levels of fork-lifts should be specified to be 85 dB(A) or less at 7m, at the procurement stage.

## 8. CONCLUSION

This acoustical impact assessment of mining operations associated with the proposed Goonumbla Project has taken into account the results of a previous field survey to determine ambient sound levels, sound propagation conditions existing in the area, and computer modelling of the future noise impact at surrounding farm properties and residences for both Stage I and Stage II operations.


The sound level predictions have been based on the least favourable atmospheric conditions. The analysis has confirmed that although the Company has stated its intention to acquire the following properties:

"Orana", "Estcourt", "Bonni Doon" (previously known as "The Overalls"), "Pinegrove", "Braeside", "Rosedale", "Altona", "Rocklands" and "Hopetoun",

the following additional properties should also be considered for either acquisition or provision of supplementary architectural acoustical treatment in order to comply with the SPCC preferred night time environmental noise criteria:

"Adavale", "Beechmore", "Fernleigh", "Milpose", "Avondale", and "Kundibah".

The noise impact at "Coradgery" and "Hill View" should be reassessed once operations begin.



Report No. 5204-3-88

Page No. 21

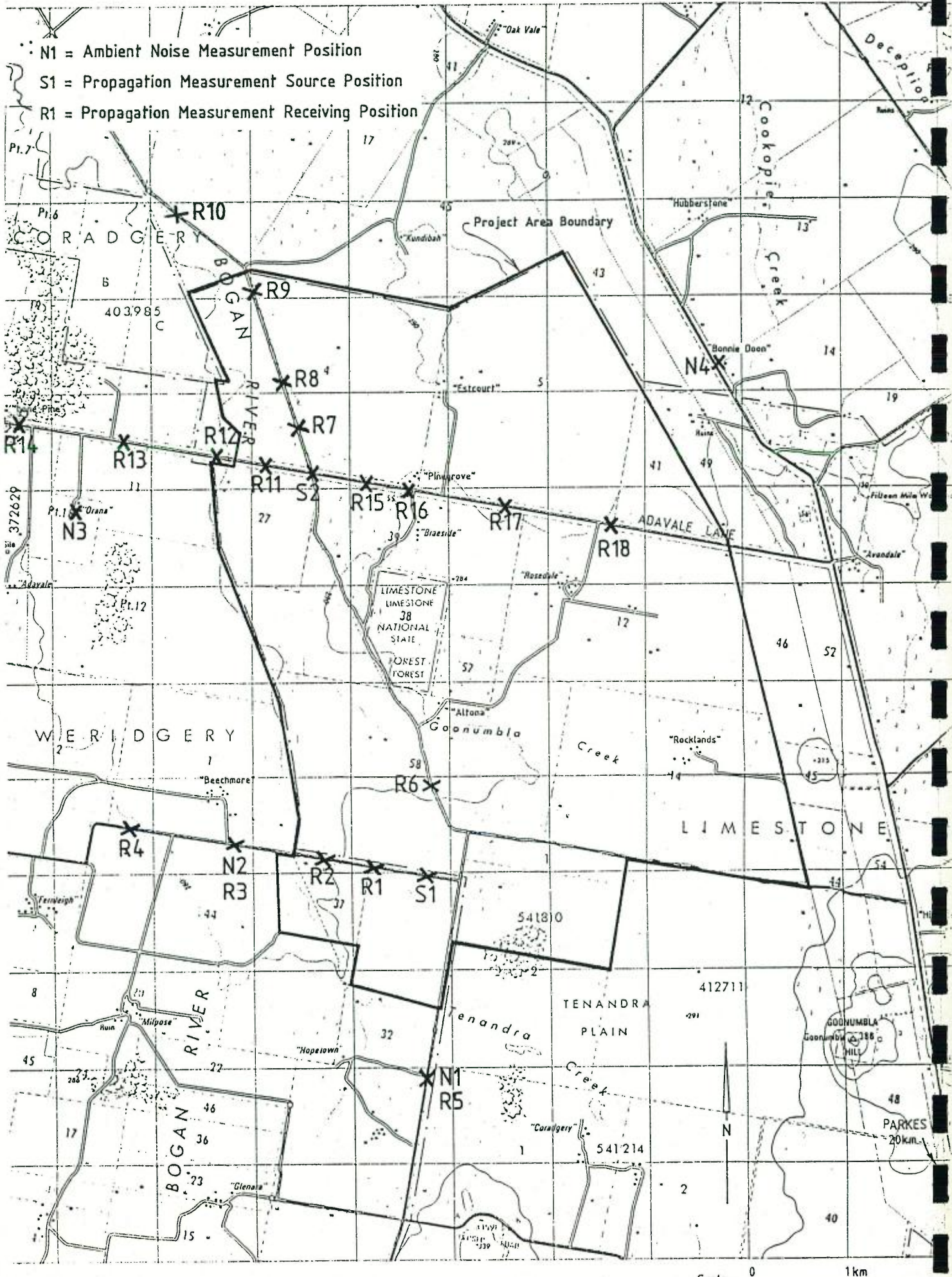
The noise of trucking activities between the mine site and the proposed rail siding is likely to result in a minimal loss of amenity for the two (2) existing residences in the Goonumbla village.

The potential acoustical impact associated with rail loading operations, which may occasionally occur at night, is expected to be environmentally acceptable at the Goonumbla village, if the siding is located at least 400m away from the nearest house.

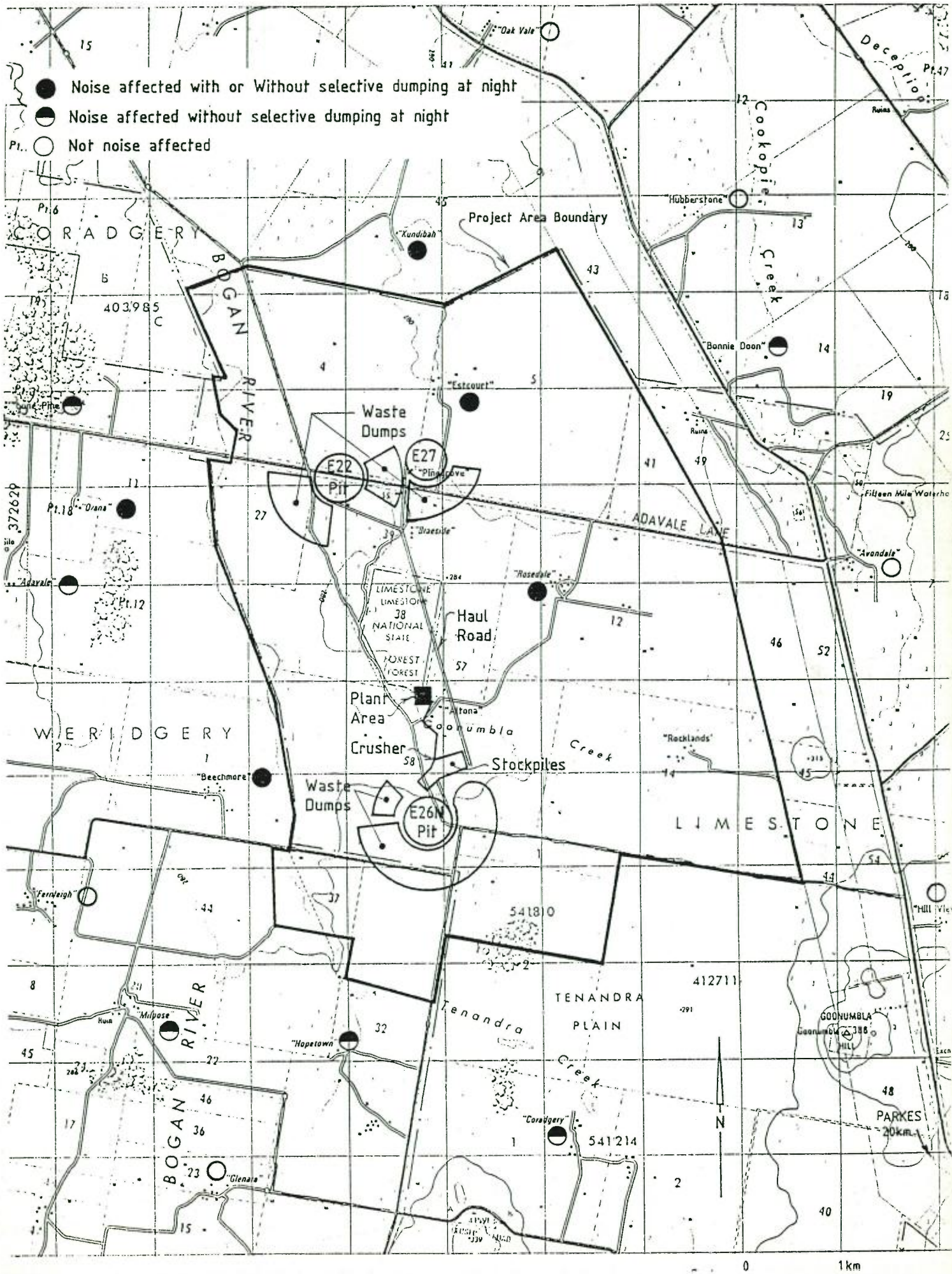
Louis A. Challis

1356A/362A/5204-3-88

# AREA PLAN SHOWING PROJECT SITE AND SOUND MEASUREMENT POSITIONS



# PROPOSED GOONUMBLA COPPER PROJECT AREA PLAN SHOWING PROPOSED DEVELOPMENT AND AFFECTED RESIDENCES



INSTRUMENTATION FOR MEASUREMENT OF AMBIENT NOISE

The ambient noise levels were measured using the following equipment:

Community Noise Analyser	Genrad Type 1945
25mm Ceramic Microphone	Genrad Type 1971-9605
protected by	
Windshield	Brüel & Kjaer Type UA 0207

The A-weighted sound level was recorded on a

Chart Recorder	Linear Type 142
----------------	-----------------

The reference level of the system was checked at frequent intervals using an Acoustic Calibrator, Brüel & Kjaer Type 4230, and remained within the range  $93 \pm 1$  dB(A). This instrument has been calibrated in our laboratory and complies with its manufacturer's specifications in terms of linearity and frequency response, and has a dynamic range greater than 90 dB(A). The measurement period is 0.22 seconds.



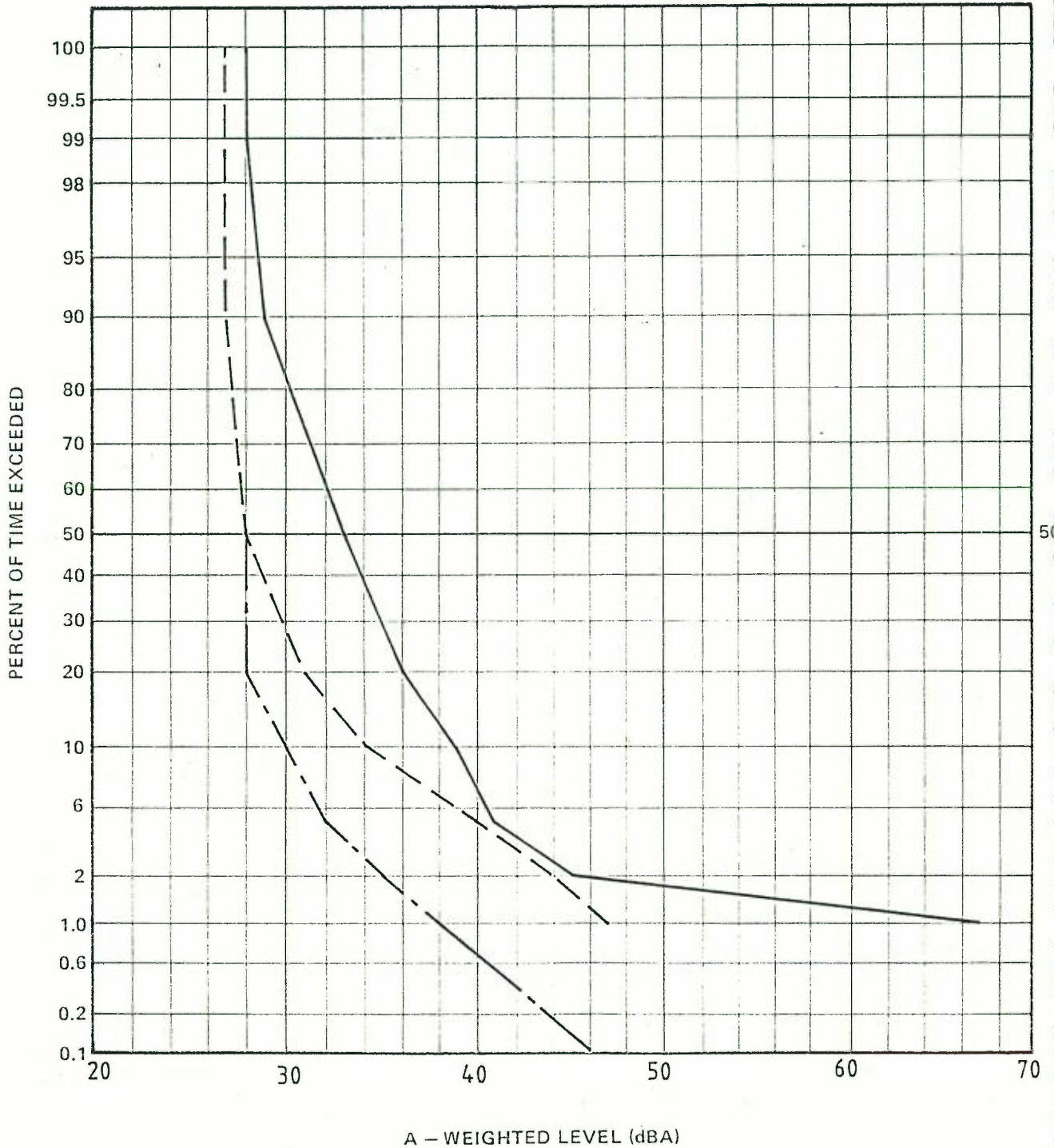
INSTRUMENTATION FOR SOUND PROPAGATION MEASUREMENTS

Sound Source Case (Random Noise Generator, Octave Filters, Audio Amplifier and Loudspeaker)	Challis Mk II
Precision Sound Level Meter and Octave Analyser fitted with a 12mm Condenser Microphone protected by a Windshield	Brüel & Kjaer type 2215  Brüel & Kjaer type 4165  Brüel & Kjaer type UA0237

The reference level of the measurement system was checked before and after the measurements using an Acoustic Calibrator, Brüel & Kjaer type 4230, and remained within the range  $93.8 \pm 0.5$  dB(A).

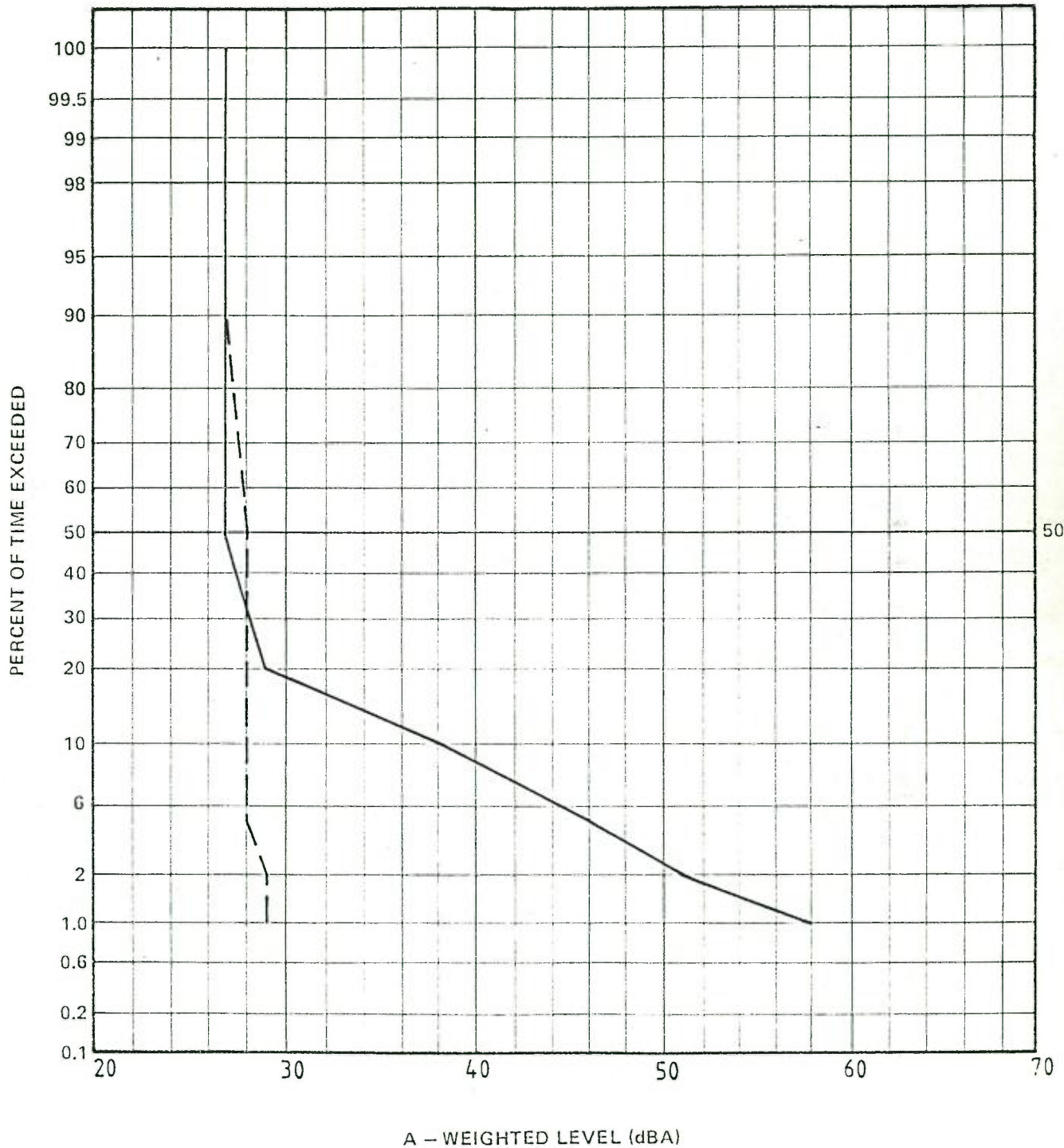
This instrument has been calibrated in our laboratory, which is registered for this test by the National Association of Testing Authorities, and complies with AS 1259, Part 2-1976 "Sound Level Meters, Type 2, Precision" and AS Z41-1969 "Octave, half octave and one third octave band pass filters intended for the analysis of sound and vibrations."

# EXISTING AMBIENT PERCENTILE SOUND LEVELS-DAYTIME POSITION 1-ENTRANCE TO "HOPETOWN"



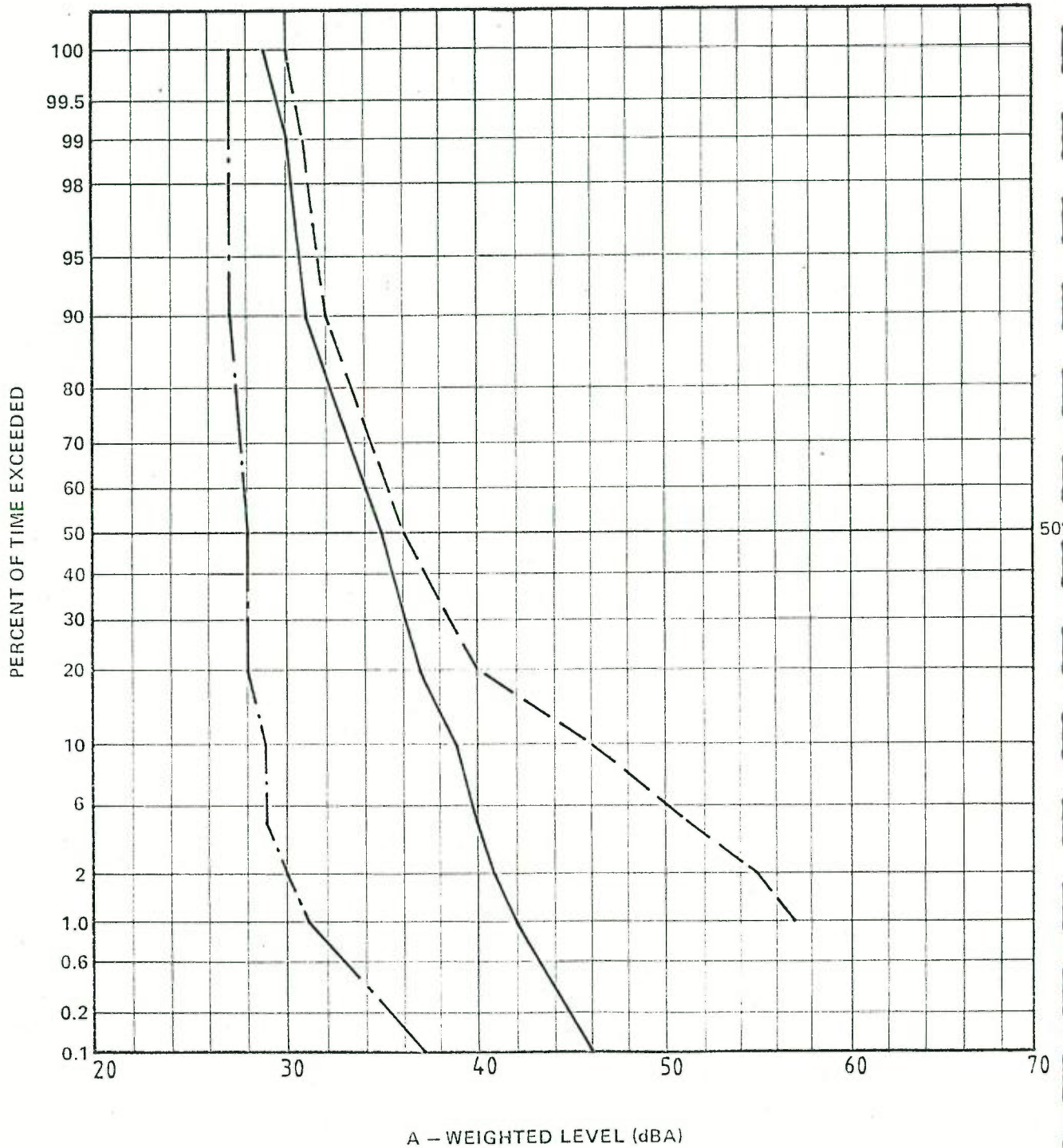
- Leq = 47dB(A) ————— 1340-1400hrs:- 1 Car & trailer, 1 Light aircraft 12/6/86
- Leq = 32dB(A) - - - - - 1510-1530hrs:- 1 Light aircraft, Sheep, Birds 12/6/86
- Leq = 29dB(A) — - — — — 1040-1100hrs:- Birds 13/6/86

### EXISTING AMBIENT PERCENTILE SOUND LEVELS-NIGHT TIME POSITION 1 - ENTRANCE TO "HOPETOWN"



Leq = 40dB(A) ————— 1915-1935hrs:- 1 Light aircraft, dogs 12/6/86  
Leq = 27dB(A) - - - - - 2025-2045hrs:- Thunder in distance 12/6/86

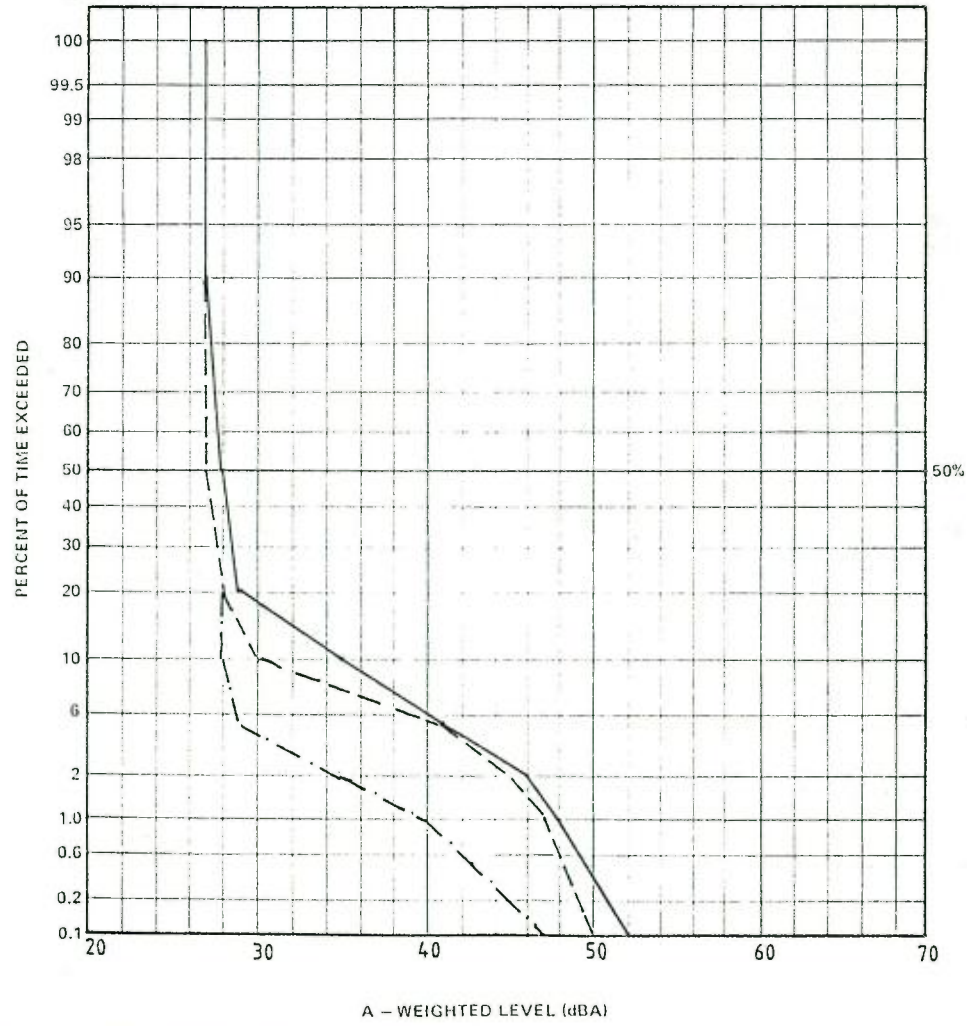
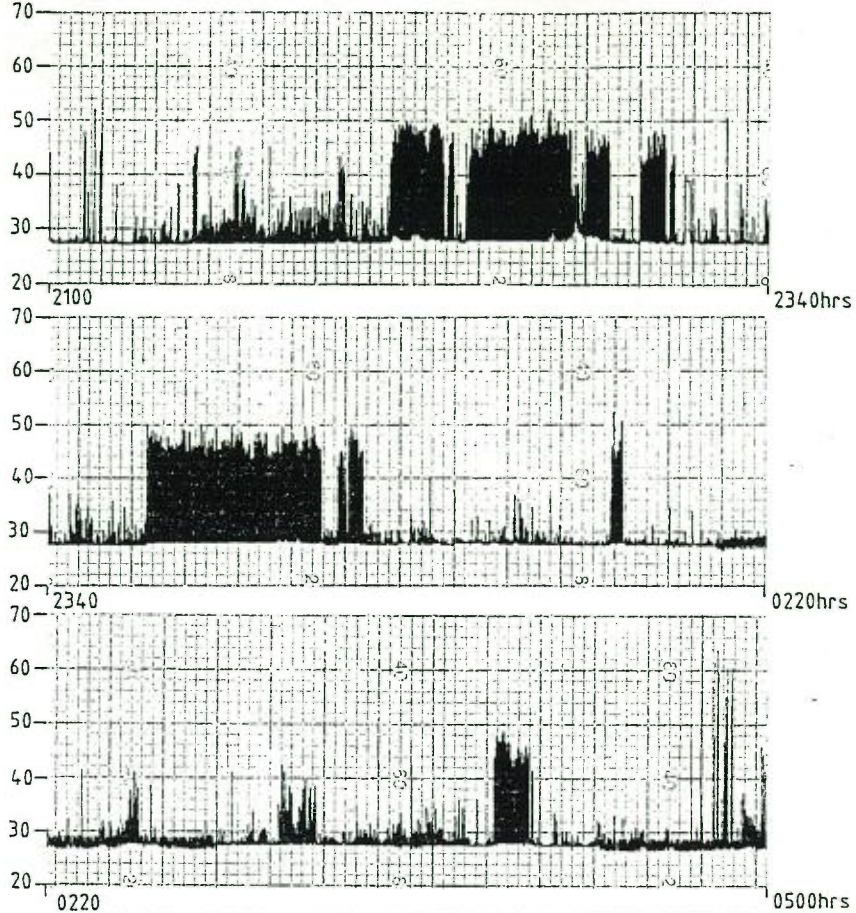
## EXISTING AMBIENT PERCENTILE SOUND LEVELS POSITION 2 - ENTRANCE TO "BEECHMORE"



Leq = 36dB(A) ————— 1423-1443hrs:- birds, sheep 12/6/86  
 Leq = 42dB(A) - - - - - 1545-1605hrs:- birds, sheep 12/6/86  
 Leq = 28dB(A) - . - . - . 1748-1808hrs:- sheep, cows 12/6/86

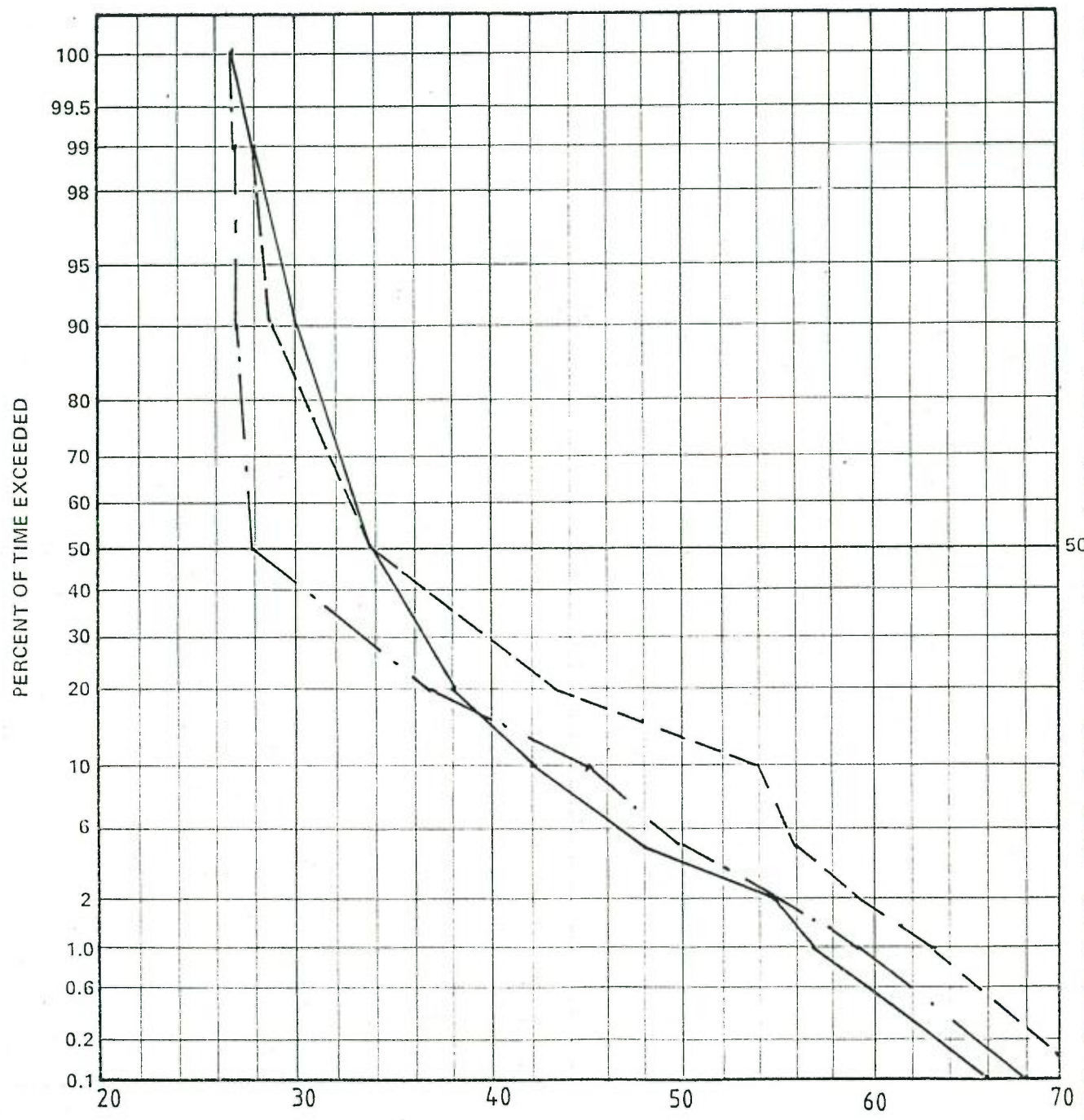
# EXISTING AMBIENT PERCENTILE SOUND LEVELS - NIGHT TIME POSITION 3 - OUTSIDE "ORANA" HOMESTEAD

dB(A) re 20µPa



Leq = 35dB(A) ————— 1st RUN - 2100-2340 hrs 10/6/86  
 Leq = 34dB(A) - - - - - 2nd RUN - 2340-0220 hrs 10-11/6/86  
 Leq = 30dB(A) - · - · - · 3rd RUN - 0220-0500 hrs 11/6/86

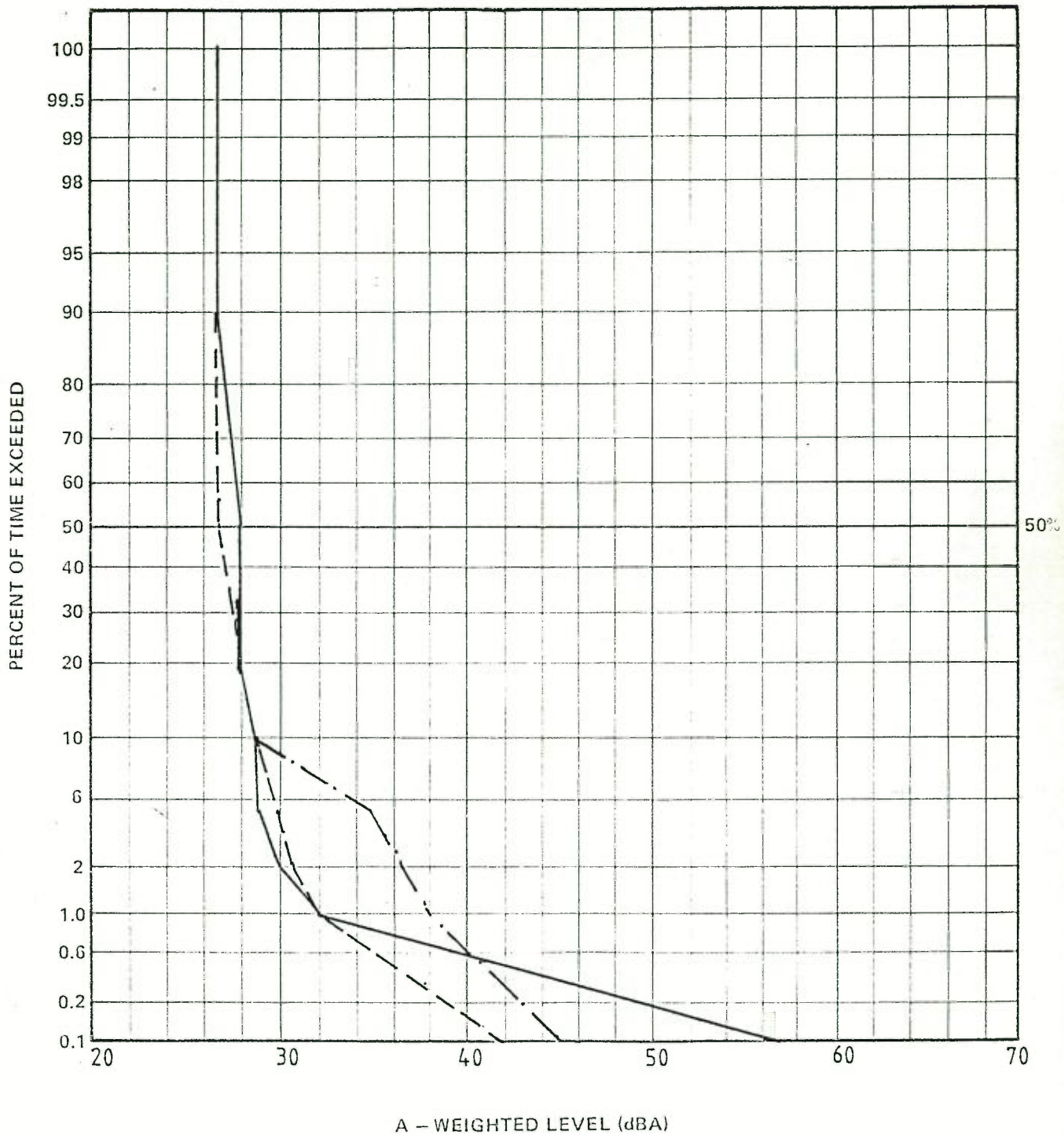
## EXISTING AMBIENT PERCENTILE SOUND LEVELS POSITION 4 - OUTSIDE "BONNIE DOON" HOMESTEAD



A - WEIGHTED LEVEL (dBA)

- Leq = 46dB(A) ————— 1st RUN - 1100-1340 hrs. 11/6/86
- Leq = 51dB(A) - - - - - 2nd RUN - 1340-1620 hrs. 11/6/86
- Leq = 46dB(A) — - - - - 3rd RUN - 1620-1900 hrs. 11/6/86

## EXISTING AMBIENT PERCENTILE SOUND LEVELS POSITION 4 - OUTSIDE "BONNIE DOON" HOMESTEAD



Leq = 32dB(A) ————— 1st RUN - 2200-0040 hrs 11-12/6/86

Leq = 28dB(A) - - - - - 2nd RUN - 0040-0320 hrs 12/6/86

Leq = 29dB(A) — - - - - 3rd RUN - 0320-0600 hrs 12/6/86

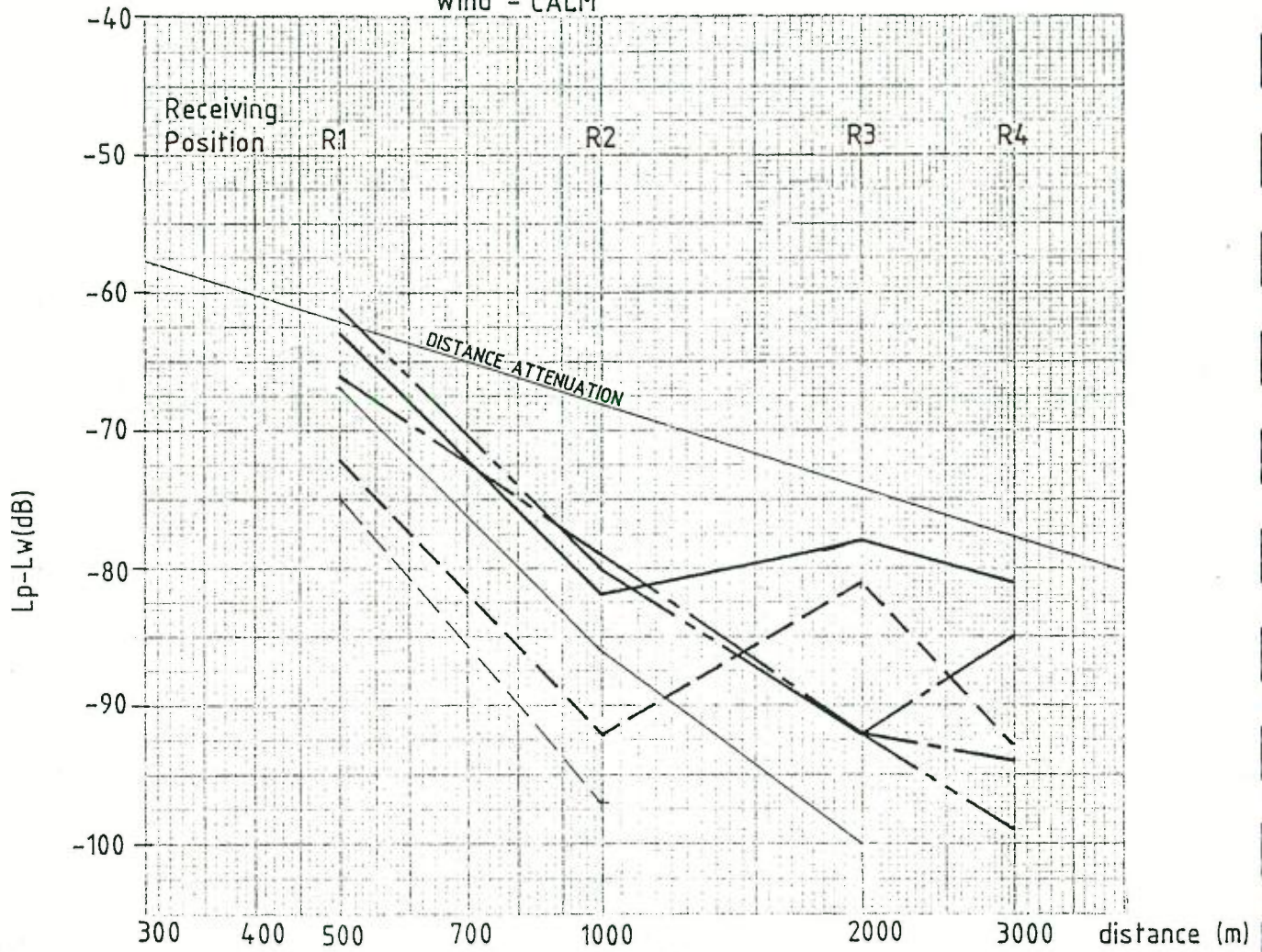
PROPAGATION TEST RESULTS - GOONUMBLA  
 SOURCE POSITION S1 - ON RISE NEAR E26N  
 TRAVERSE - WEST TOWARDS "BEECHMORE"

TIME - 10/6/86, 2200-2400hrs

Temperature - 3.5-6°C

Relative Humidity - 90%

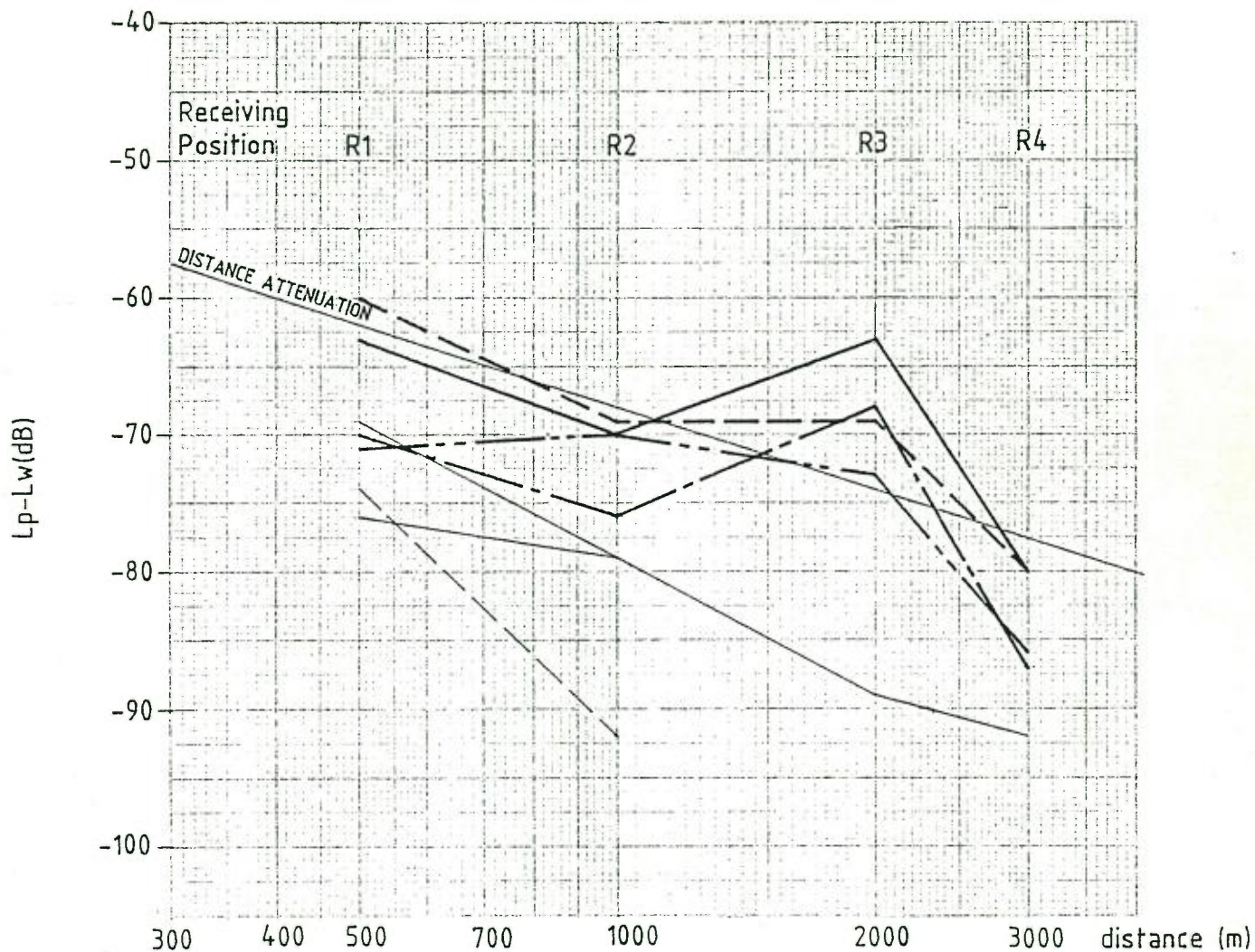
Wind - CALM



- 125Hz
- - - - - 250Hz
- 500Hz
- - - - - 1kHz
- 2kHz
- - - - - 4kHz

PROPAGATION TEST RESULTS - GOONUMBLA  
SOURCE POSITION S1 - ON RISE NEAR E26N  
TRAVERSE - TOWARDS "BEECHMORE"  
TIME - 12/6/86, 0400-0530hrs

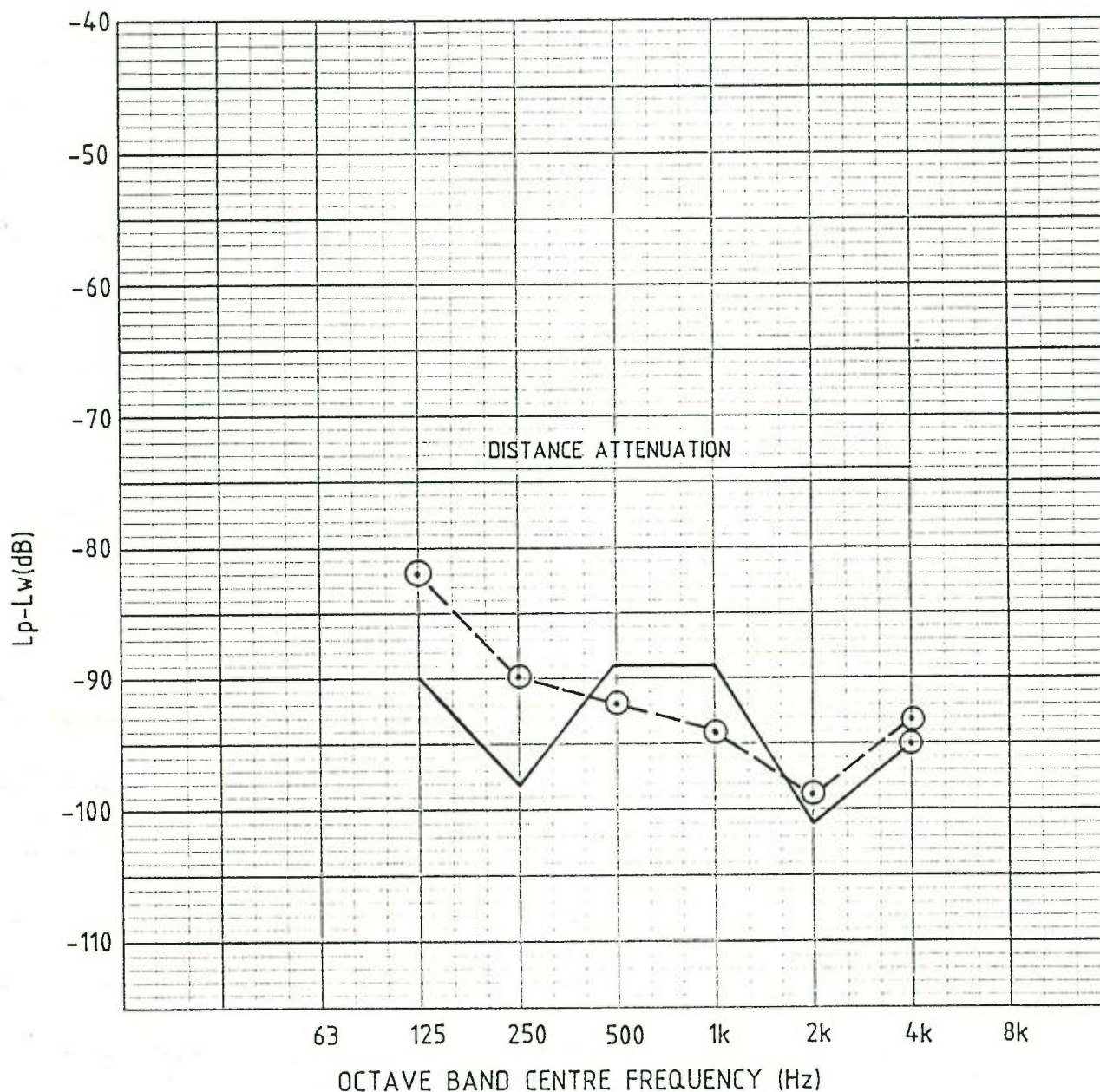
Temperature - 5-6.5°C  
Relative Humidity - 85-100%  
Wind - CALM



- 125Hz
- - - - - 250Hz
- · — · — 500Hz
- · — · — 1kHz
- 2kHz
- - - - - 4kHz



PROPAGATION TEST RESULTS - GOONUMBLA  
SOURCE POSITION S1 - ON RISE NEAR E26N  
TRAVERSE - SOUTH OVER RISE TOWARDS "HOPETOWN"  
POSITION R5 - 2000m FROM SOURCE



————— 11/6/86, 0005hrs, Temperature - 4.5°C,  
Relative Humidity - 90%, Wind - CALM.

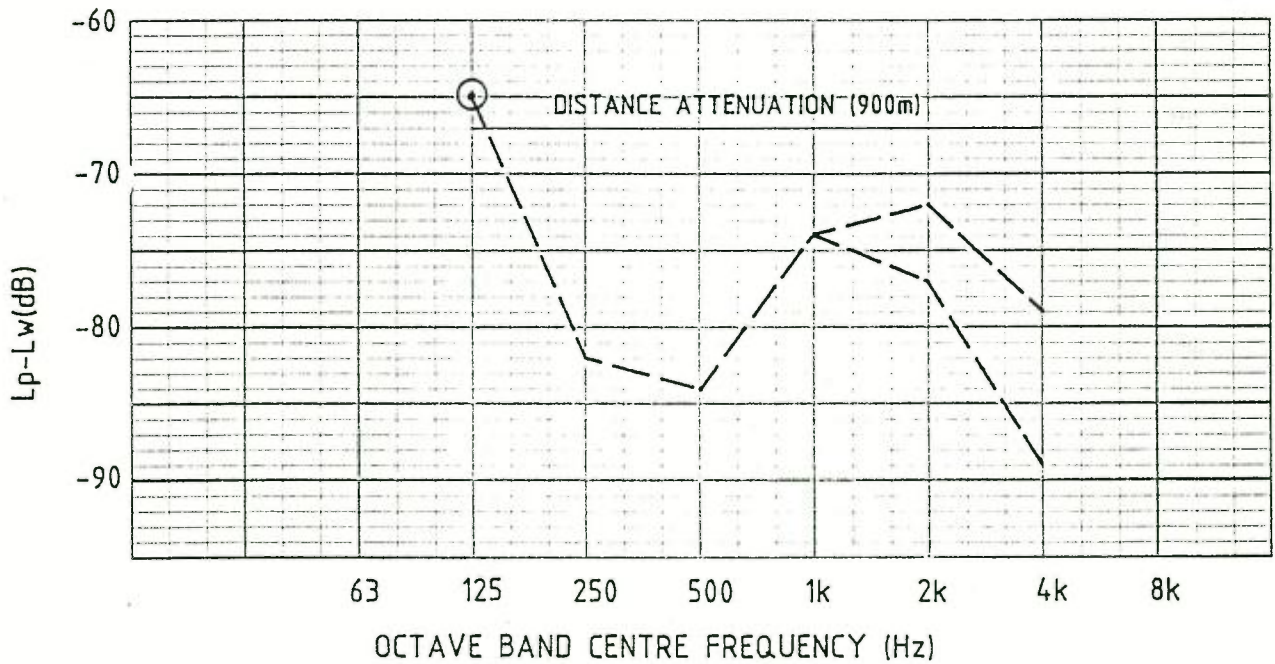
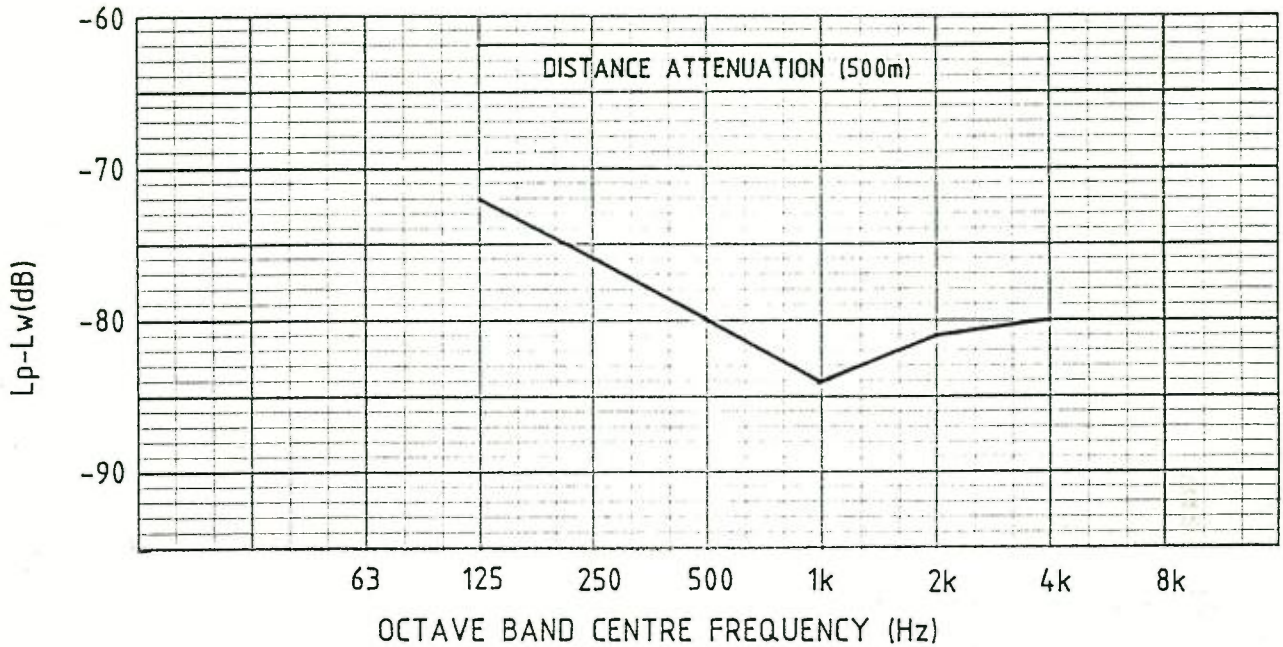
- - - - - 12/6/86, 0545hrs, Temperature - 5.5°C,  
Relative Humidity - 100%, Wind - CALM.

NOTE: ○ DENOTES RESULTS INDISTINGUISHABLE ABOVE BACKGROUND NOISE



PROPAGATION TEST RESULTS - GOONUMBLA  
 SOURCE POSITION S1 - ON RISE NEAR E26N  
 TIME - 11/6/86, 1245-1500hrs

Temperature - 17°C  
 Relative Humidity - 62%  
 Wind - 10-15km/h from South



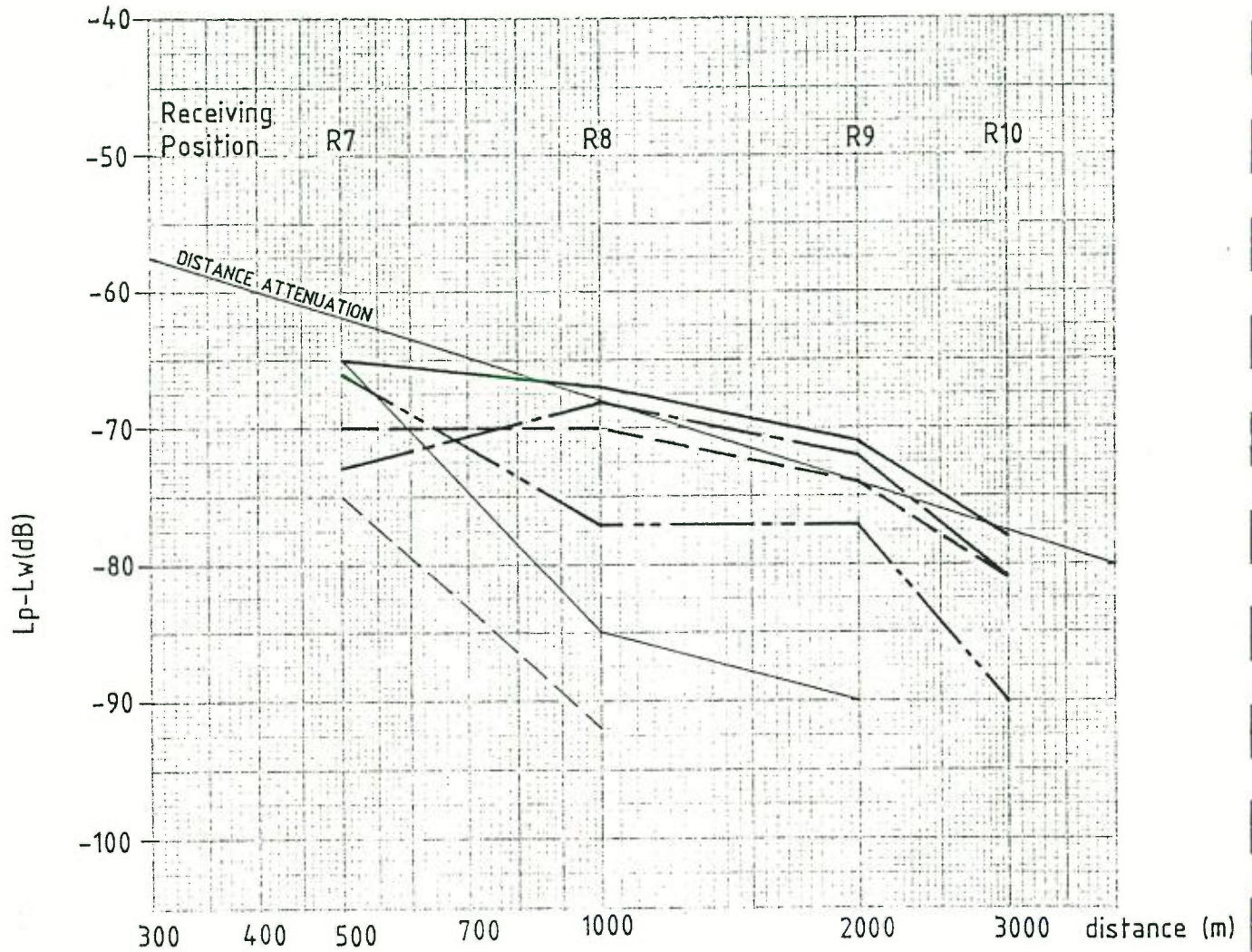
- POSITION R1, 500m WEST OF S1, WITH CROSS WIND.
- - - - - POSITION R6, 900m NORTH OF S1, OVER SLIGHT RISE, DOWNWIND.

NOTE: ⊙ DENOTES RESULT INDISTINGUISHABLE ABOVE BACKGROUND NOISE.



PROPAGATION TEST RESULTS - GOONUMBLA  
SOURCE POSITION S2 - ADAVALE LANE, ROAD JUNCTION NEAR E22/27  
TRAVERSE - N/W  
TIME - 12/6/86, 0630-0730hrs

Temperature - 5°C  
Relative Humidity - 100%  
Wind - CALM



- 125Hz
- - - - - 250Hz
- · - · - 500Hz
- - - - - 1kHz
- 2kHz
- - - - - 4kHz



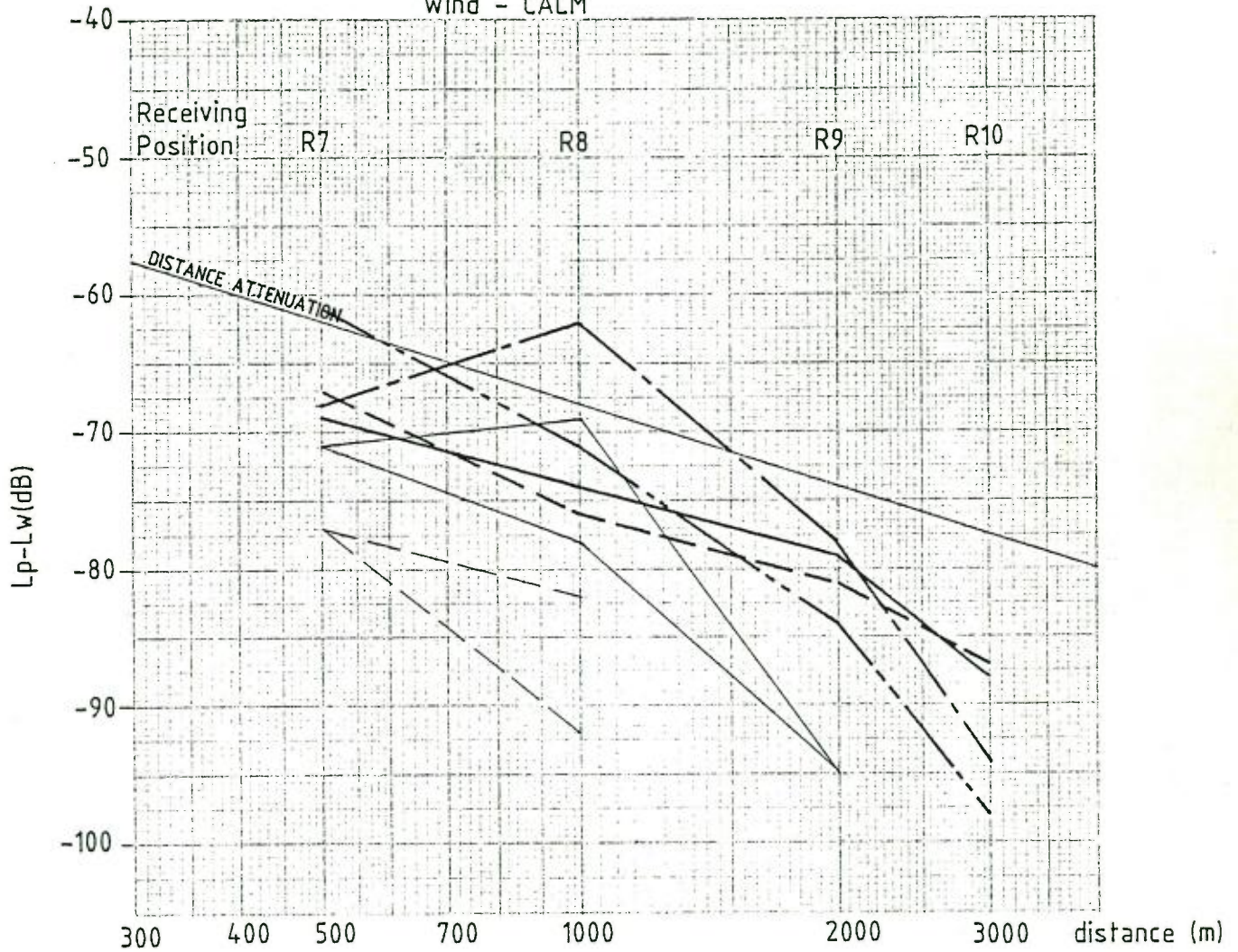
PROPAGATION TEST RESULTS - GOONUMBLA  
SOURCE POSITION S2 - ADAVALE LANE, ROAD JUNCTION NEAR E22/27  
TRAVERSE - N/W

TIME - 13/6/86, 0400-0500hrs

Temperature - 3-4°C

Relative Humidity - 100%

Wind - CALM

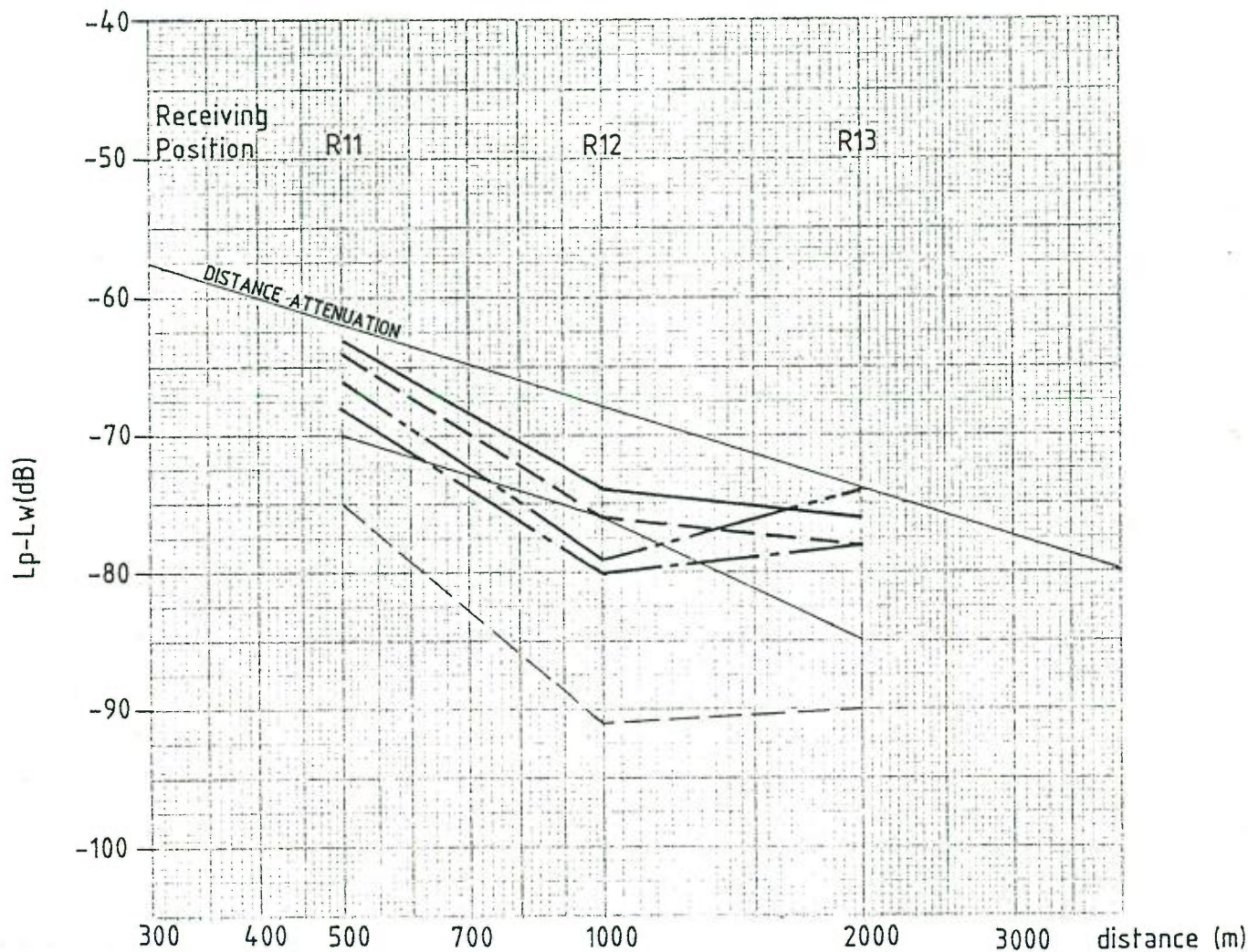


- 125Hz
- - - - - 250Hz
- . - . - 500Hz
- . - . - 1kHz
- 2kHz
- - - - - 4kHz

# PROPAGATION TEST RESULTS - GOONUMBLA

SOURCE POSITION S2 - ADAVALE LANE, ROAD JUNCTION NEAR E22/27  
TRAVERSE - WEST TOWARDS "LONE PINE"  
TIME - 12/6/86, 0730-0800hrs

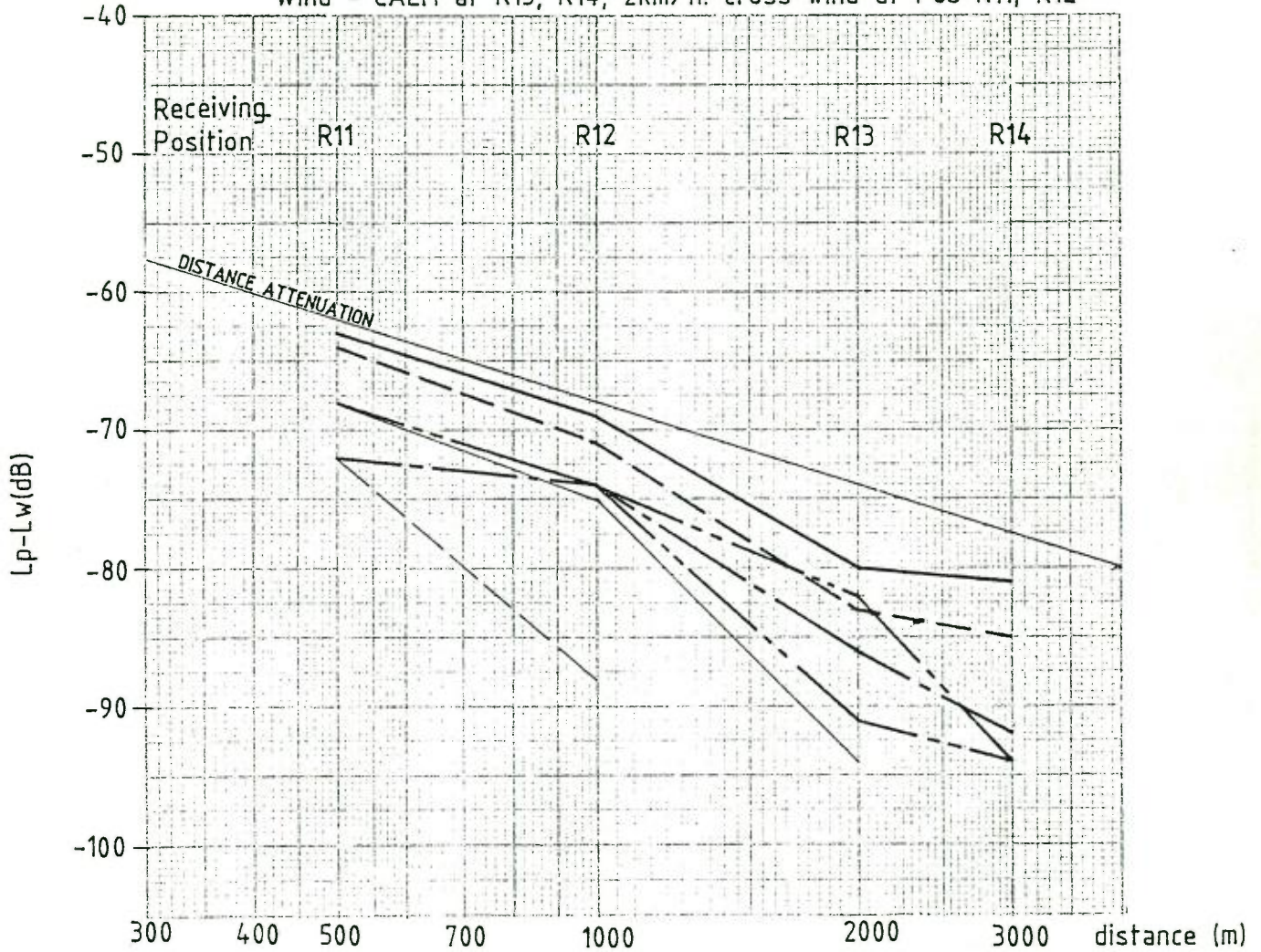
Temperature - 4°C  
Relative Humidity - 100%  
Wind - CALM, 2km/h at Pos, R13



- 125Hz
- - - - - 250Hz
- . - . - 500Hz
- - - - - 1kHz
- 2kHz
- - - - - 4kHz

PROPAGATION TEST RESULTS - GOONUMBLA  
SOURCE POSITION S2 - ADAVALE LANE, ROAD JUNCTION NEAR E22/27  
TRAVERSE - WEST TOWARDS "LONE PINE"

TIME - 13/6/86, 0500-0600hrs  
Temperature - 4-4.5°C  
Relative Humidity - 100%  
Wind - CALM at R13, R14, 2km/h. cross wind at Pos R11, R12

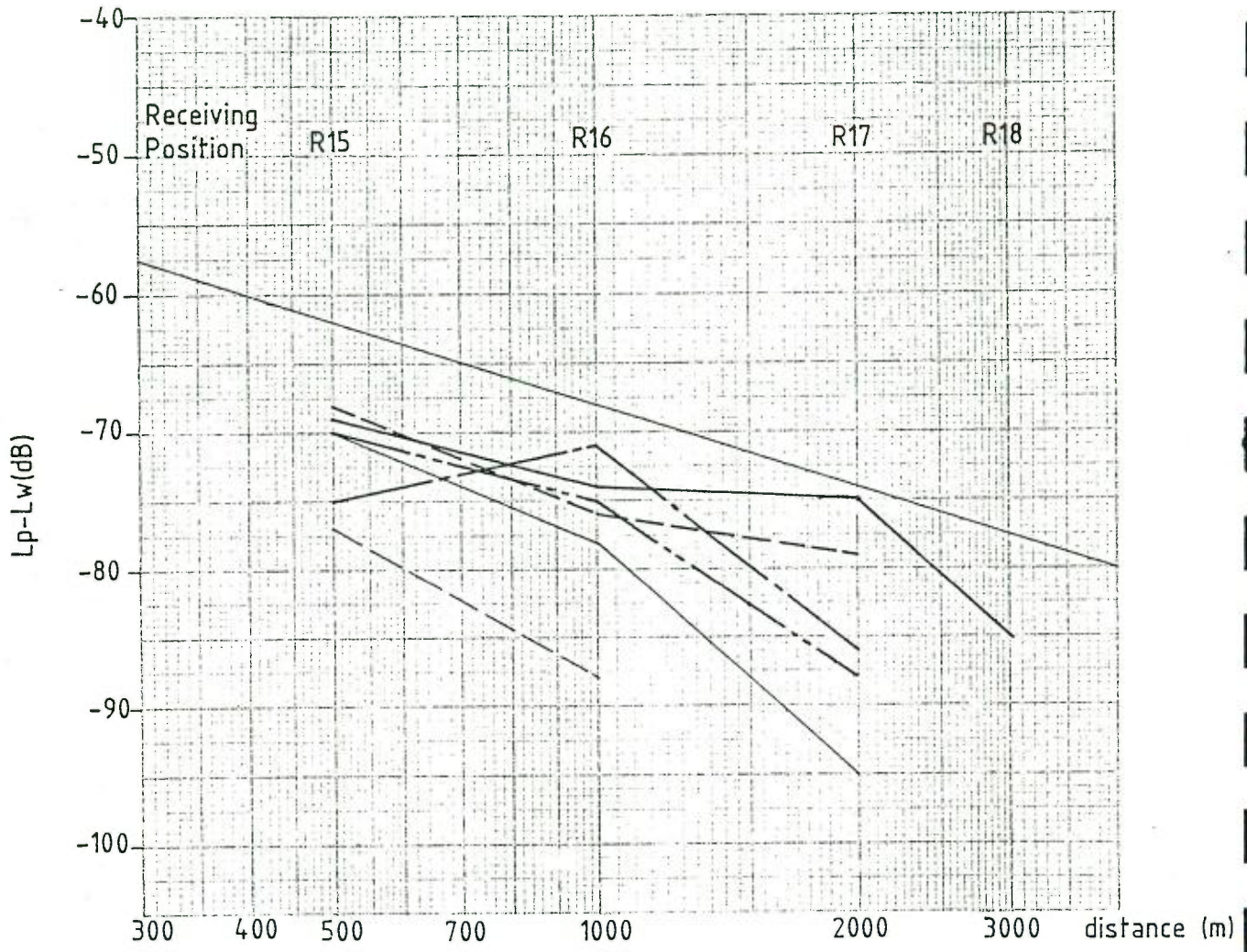


- 125Hz
- - - - - 250Hz
- . - . - 500Hz
- - - - - 1kHz
- 2kHz
- - - - - 4kHz

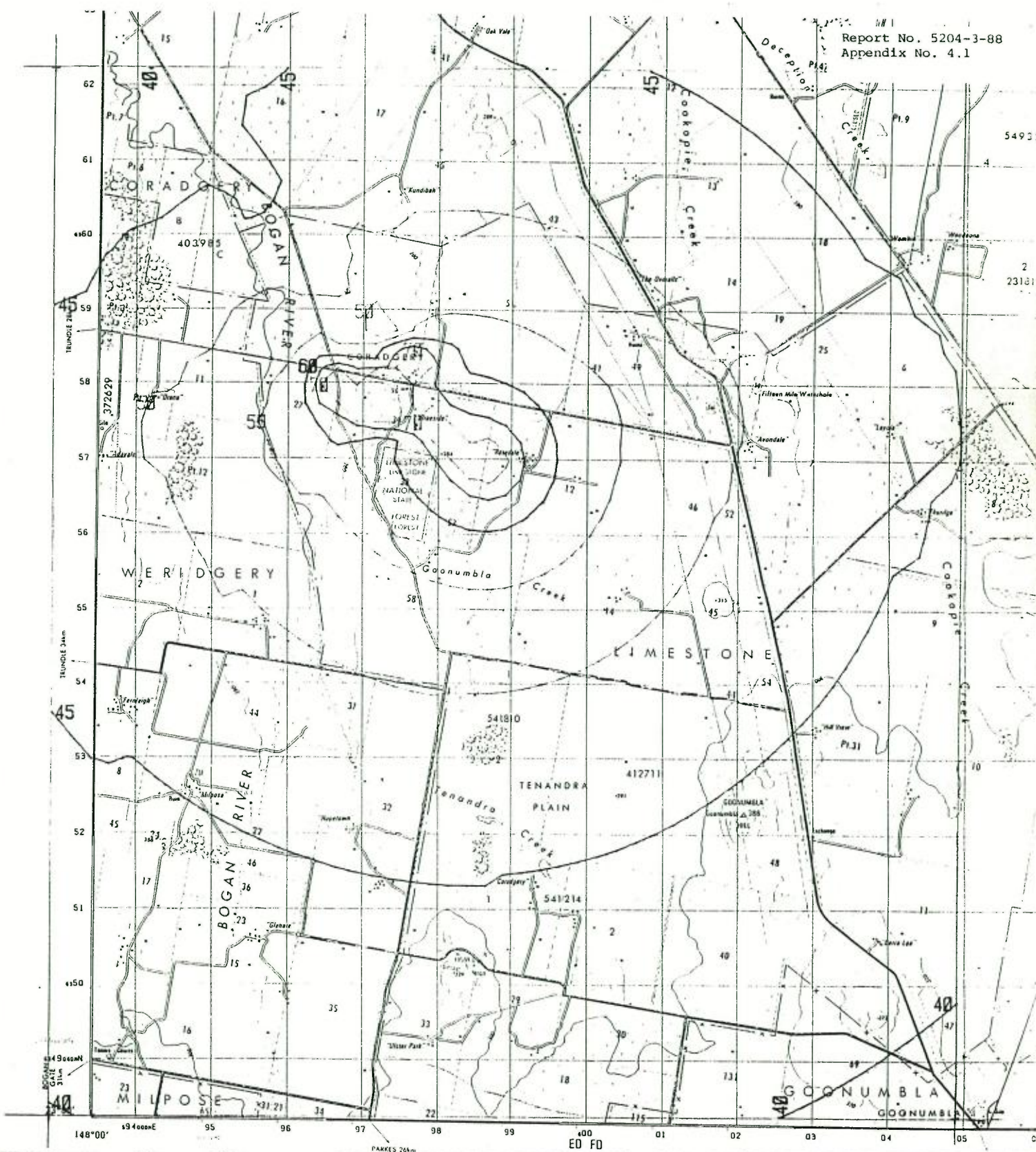


PROPAGATION TEST RESULTS - GOONUMBLA  
SOURCE POSITION S2 - ADAVALE LANE  
TRAVERSE - EAST TOWARDS "AVONDALE"  
TIME - 13/6/86, 0630-0700hrs

Temperature - 1.5-4°C  
Relative Humidity - 100%  
Wind - CALM



- 125Hz
- - - - - 250Hz
- . - . - 500Hz
- - - - - 1kHz
- 2kHz
- - - - - 4kHz



5493

2  
23181

148°00' 1940000E 95 96 97 98 99 00 01 02 03 04 05

PARKES 20km

ED FD



**APPENDIX I**

**DUST DISPERSION MODELLING**

Natural Systems Research Pty. Ltd.

**PARKES JOINT VENTURE  
DUST DISPERSION MODELLING**

Prepared by : Natural Systems Research Pty. Ltd.  
(Environmental Consultants)  
25 Burwood Road  
HAWTHORN Vic. 3122

For : Parkes Joint Venture

Date : June 1986

Report : CR 312/2

## CONTENTS

- 1.0 INTRODUCTION
- 2.0 DUST MODELLING
- 3.0 DUST EMISSIONS
  - 3.1 Worst Case Dust Emission
- 4.0 RELEVANT METEOROLOGY
- 5.0 MODELLING
  - 5.1 Results
  - 5.2 Dust Impact
- 6.0 REFERENCES

### APPENDICES

- Appendix 1 Activity levels
- Appendix 2 Wind speed-direction-stability analysis
- Appendix 3 Total dust mass factors
- Appendix 4 Fortran program to evaluate dust concentration

## 1.0 INTRODUCTION

Peko-Wallsend Operations Ltd., on behalf of the Joint Venture Partners, are presently exploring an area of copper mineralization under licence near Parkes in Central New South Wales. Environmental studies related to proposed open pit mining activity commenced in November 1981 and have continued to the present.

One of the objectives in the design of the environmental monitoring programme was the establishment of background dust levels in the area. To this end, a network of dust gauges, as specified in NSR (1985) have been in operation.

Nevertheless, the New South Wales State Pollution Control Commission (SPCC) favour estimates of likely future dust impacts on the basis of mathematical modelling, and this document provides the results of a preliminary dust modelling exercise.

## 2.0 DUST MODELLING

The SPCC has developed and is continuing to refine a computer model that can simulate dust deposition from individual mines. The approach used has been to modify a computer dispersion model, CDMQC, developed by the United States Environmental Protection Authority to enable it to simulate dust deposition. Details of the SPCC application of this model to coal mining are given by SPCC (1983).

### 2.1 Simplified Methodology

Application of the full CDMQC dust model requires extensive meteorological input combined with detailed specification of the location of each dust emitter and the quantity to be emitted. In this document, preliminary estimates of dust deposition are obtained by using a simplified methodology in which the dust is taken as a completely conservative substance whose mass is distributed according to the wind speed, wind direction and stability classes obtained from anemograph data and also according to the fallout functions given by PEDCo (1978).

## 3.0 DUST EMISSIONS

Predicted dust concentrations are directly related to the pollutant mass-emission rate. The USEPA has published two reports (PEDCo 1978; Axetell and Cowherd, 1981) on emission rates at open cut coal mines in the US western coalfields. The NSW SPCC has developed emission rates applicable to NSW coal mines on the basis of these reports. These emission rates are given in Table 1.

There are no figures available that are applicable to mines other than coal mines, therefore the figures of Table 1 have been used for the Goonumbla project.

John Tankard & Associates (1986) have quantified project activity levels on a per quarter basis, and their report is given in Appendix 1.

**TABLE 1**  
**SPCC EMISSION RATES**  
 Source: SPCC (1983)

Haul trucks	4.0 kg per vehicle kilometre travelled
Blasting of overburden and coal	Blast (kg, blast) = $\frac{758 A^{0.8}}{M^{1.9} D^{1.8}}$ where A is area to be blasted (m <sup>2</sup> ), D is the depth of blast (m) and M is the moisture content (%)
Loading by truck and shovel: overburden coal	0.01 kg per tonne of overburden 0.02 kg per tonne of coal
Drilling	0.6 kg per hole
Truck dumping: overburden coal	0.02 kg per tonne of material 0.06 kg per tonne of material
Exposed areas	0.4 kg per hour per hectare
Top-soil removal	14 kg per scraper hour
Dragline	0.02 kg per m <sup>3</sup> of material

### 3.1 Worst Case Dust Emission

The annual values for dust generating activities during the year of maximum activity have been extracted from the data of Appendix 1, and are given in Table 2.

**TABLE 2**  
**MAXIMUM EXPECTED ACTIVITY LEVELS AND THEIR RESULTANT DUST LOADINGS**

Activity	Maximum Annual Value	Unit Emission Factor	Total Annual Dust (tonnes)
Haul Roads			
In-pit	230.8 x 10 <sup>3</sup> veh-km	1.2 kg/veh-km (1)	277
Surface	390.5 x 10 <sup>3</sup> veh-km	4 kg/veh-km	1 562
Blasting	75 blasts	251 kg/blast (2)	19
Loading	7.83 x 10 <sup>6</sup> tonnes	.01 kg/tonne (3)	78
Drilling	4628 holes	0.6 kg/hole	3
Dumping	7.83 x 10 <sup>6</sup> tonnes	.02 kg/tonne (3)	157
Exposed areas	311.60 ha	0.4 kg/hr/ha 3.5 tonne/ha/yr (4)	1 091
Exposed pits	53.60 ha	1.05 tonne/ha/yr (1)	56
Exposed tailings	154 ha	3.5 tonne/ha/yr	539
Top-soil removal	1 scraper	14 kg/scraper-hr (5)	68
MAXIMUM TOTAL ANNUAL DUST LOAD			3 850

Notes

- (1) A pit-retention factor of 0.7 has been used.
- (2) Blasting analysis is based on figures in Table 3 of Appendix 1 that indicate an average of 65 800 square metres will be subject, over the year, to an average of 19.5 blasts. This corresponds to 3 374 square metres per blast. Each blast has a depth of 12.5 m and it was assumed that the moisture content was also a constant 5%.  
  
Substitution into the blasting equation of Table 1 yields an emission factor of 251 kg per blast.
- (3) The values relating to overburden have been used as appropriate emission factors.
- (4) Based on exposure for 24 hours over 365 days.
- (5) Based on scraper operation for 1218.75 hours per quarter (i.e. 4875 hours per year).

#### 4.0 RELEVANT METEOROLOGY

From 1 December 1982 to 28 February 1985 there were 5253 three-hourly meteorological observations collected, as well as 1083 observations that lacked data. These observations have been analysed in terms of stability category A to G; wind speed in four classes (0-3 knots; 4-7 knots; 8-12 knots and greater than 12 knots) and wind direction in 16 compass points. The tabulation is given in Appendix 2.

#### 5.0 MODELLING

PEDCo (1978) recommend that the deposition of small airborne particles be modelled by a source depletion factor.

$$Q_x / Q_0 = \exp [- a v_d x^b / u] \quad (1)$$

where

$Q_x$  = effective emission rate at distance x  
 $Q_0$  = emission rate at x = zero  
a, b = constants which are a function of stability class

$v_d$  = settling velocity in cm/s,  
u = wind speed in m/s.

Constants for each stability class are given in Table 3.

TABLE 3  
SOURCE DEPLETION CONSTANTS (PEDCo, 1978)

Stability Class	a	b
A	0.120	0.14
B	0.135	0.15
C	0.183	0.18
D	0.115	0.30
E	0.160	0.30
F	0.114	0.40

Dust modelling then proceeds as follows:

Let  $N_t$  represent the total number of meteorological observations which is 5253 in this case. Over the course of a year  $M_t = 3850$  tonnes of dust will be emitted so that each meteorological observation corresponds to the transport of  $M_t/N_t$  mass units of dust. This means that a dust load can be associated with each of the totals of Appendix 2.

However, the total dust is distributed according to the source depletion function of equation (1). Each meteorological observation distributes the total mass in such a way that all observations (i.e.  $N_t$ ) summed over all distances, wind speed classes, directions and stabilities must total  $M_t$ . Thus for a particular wind speed, direction, stability class

$$M_t/N_t = f \int_0^{\infty} \exp(-a v_d x^b / u) dx \quad (2)$$

where  $f$  is a mass factor that depends on stability class, wind speed and settling velocity. This report follows the recommendation in PEDCo (1978) and sets  $v_d = 5$  cm/s. For evaluation of equation (2) see Appendix 3.

The quantity

$$F(x) = f \exp[-a v_d x^b / u]$$

then represents the mass density, in units of mass per unit length.

The dust deposition at any distance in one of the sixteen compass directions is then obtained by multiplying  $F(x)$  by the number of observations corresponding to that stability class ( $s$ ), wind speed class ( $u$ ) and direction ( $\phi$ ); dividing by the length of the sector which is  $(\pi/8)x$  in the case of a sixteen point compass - converting the result from tonnes per square metre per year to grams per square metre per month and summing all the stability and wind speed classes:

$$D(\phi) = (8/\pi x) \sum_{s,u} N(s, u, \phi) f \exp(-a v_d x^b / u)$$

Four wind speed classes were used in the analysis. These were 0 to 3 knots, 4 to 7 knots, 8 to 12 knots and greater than 12 knots. The appropriate values of wind speed ( $u$ ) were set as 3 knots, 5.5 knots, 10 knots and 12 knots.

## 5.1 Results

Table 4 lists the dust concentration results obtained using the procedure detailed above. The major contribution to the dust deposition comes from low wind speed events during stability category D. As most of the low wind speed, category D events are associated with winds from the south and south-southwest, these wind directions produce the greatest dust deposition.

**TABLE 4**  
**WORST CASE DUST CONCENTRATION RESULTS (g/m<sup>2</sup>/month)**

Wind Direction	Dust Vector	100 m	200 m	500 m	1 km	2 km
NNE	SSW	48.1	18.9	5.1	1.8	0.6
NE	SW	79.7	28.9	6.9	2.2	0.6
ENE	WSW	70.1	25.6	6.2	2.0	0.6
E	W	63.7	25.1	6.8	2.4	0.8
ESE	WNW	41.3	15.3	3.8	1.2	0.4
SE	NW	29.0	10.7	2.6	0.8	0.3
SSE	NNW	37.2	13.6	3.3	1.0	0.3
S	N	153	55.9	13.3	4.1	1.2
SSW	NNE	151	55.0	13.2	4.2	1.2
SW	NE	94.6	36.4	9.5	3.2	1.0
WSW	ENE	62.0	23.8	6.2	2.1	0.7
W	E	35.7	13.7	3.6	1.2	0.4
WNW	ESE	32.7	12.6	3.3	1.1	0.4
NW	SE	6.6	2.6	0.7	0.3	0.1
NNW	SSE	13.3	5.2	1.4	0.5	0.2
N	S	13.0	5.3	1.5	0.6	0.2

## 5.2 Dust Impact

The results of Table 4 indicate that dust concentrations greater than 4 g/m<sup>2</sup>/month will always be restricted to distances less than 1.1 km from the dust source. The greatest dust impact will occur to the north of a dust source with lesser impacts in other directions.

Table 2 suggests that surface haul roads and exposed areas are the major dust sources. Provided the haul roads and exposed areas are located within the central portion of the mine development area, then it will be possible to minimise any dust impact.

As a general rule of thumb, the dust impact from mining activities will be restricted to a zone 600m from the activity towards the southern sector and to a zone 1.1 km from the activity in the northern sector. These figures are, however, conservative in that they refer to the year of greatest dust generating activity and also treat all dust sources as aggregated at one point.

Furthermore, the haul road emissions refer to unwatered haul roads. In practice haul road watering will take place and the dust impact zone would be expected to be considerably less than the above distances.

## 6.0 REFERENCES

- Axetell, K. Cowherd, C.  
Improved Emission Factors for Fugitive Dust from Western Surface Coal Mining Sources. Report to USEPA, November 1981.
- Natural Systems Research Pty. Ltd. (NSR)  
Parkes Joint Venture: Goonumbla Project Dust Gauge Siting. Report CR312/1, December 1985.
- PEDCo  
Survey of Fugitive Dust from Coal Mines. Report EPA-908/1-78-003 to U.S. EPA, February 1978.
- State Pollution Control Commission (SPCC)  
Air Pollution from Coal Mining and Related Developments. SPCC, Sydney, December 1983.
- Tankard, John & Associates  
Dust Dispersion Modelling Factors. Report on Goonumbla Project, May 1986 (reproduced in Appendix 1).

**APPENDIX 1**

Activity levels  
(Report by John Tankard & Associates)

GOONUMBLA  
DUST DISPERSION MODELLING FACTORS

John Tankard & Associates

May 1986

## Haul Trucks

Total distance travelled by haul trucks on a quarterly basis is shown in attached Tables 1 & 2.

Table 1 shows distance travelled in-pit, that is, below natural ground surface.

Table 2 shows distances travelled on surface and on dumps.

To obtain averages.

- (1) Daily - divide by 62.5 days/quarter
- (2) Shift - divide (1) by 3 shifts/day
- (3) Hour - divide (2) by 6.5 hrs/shift

Peak rates of say 20 percent above average could be expected on an hourly basis.

km.inpit  
goonumbia  
6th May 1986

DISTANCE TRAVELLED BY HAUL TRUCKS  
IN-PIT  
(km '000)

TABLE 1

PROJECT YEAR QUARTER MATERIAL	PIT TOTAL (km '000)	PPD E26N												
		-2 4	-1 1	-1 2	-1 3	-1 4	1 1	1 2	1 3	1 4	2 1	2 2	2 3	
IN-PIT E26N	Ore	405.0				9.7	13.5	14.0	15.8	17.8	17.7	15.2	18.8	20.1
	Waste	494.1	28.7	32.0	24.3	25.4	32.8	35.6	35.9	29.4	33.3	36.7	37.2	
	Sub-total	899.1	28.7	32.0	34.0	38.9	46.8	51.4	53.7	47.1	48.5	55.5	57.3	
E27	Ore	264.2												
	Waste	326.5												
	Sub-total	590.7												
E22	Ore	139.2												
	Waste	268.4												
	Sub-total	407.6												
TOTAL IN-PIT			28.7	32.0	34.0	38.9	46.8	51.4	53.7	47.1	48.5	55.5	57.3	

														PPD E27				
2 4	3 1	3 2	3 3	3 4	4 1	4 2	4 3	4 4	5 1	5 2	5 3	5 4	6 1	6 2	6 3	6 4	7 1	
19.5	24.2	23.1	30.0	31.4	25.9	24.0	26.6	28.4	29.3									
33.4	32.0	22.1	18.3	17.3	8.9	6.7	3.2	0.4	0.5									
52.9	56.2	45.2	48.3	48.7	34.8	30.7	29.8	28.8	29.8									
						6.2	19.3	26.2	25.4	1.8	11.0	13.9	12.7	13.8	13.8	14.7	16.1	
						6.2	19.3	26.2	27.2	25.4	25.6	19.9	21.3	23.8	17.1	19.8	18.7	
						6.2	19.3	26.2	27.2	25.4	36.6	33.8	34.0	37.6	30.9	34.5	34.8	
52.9	56.2	45.2	48.3	48.7	34.8	36.9	49.1	55.0	57.0	36.6	33.8	34.0	37.6	30.9	34.5	34.8	34.9	

T A B

														PPD E22			
7 2	7 3	7 4	8 1	8 2	8 3	8 4	9 1-4	10 1-4	11 1-4	12 1-4	13 1-4	14 1-4	15 1				
19.5	22.0	23.7	19.8	26.0	21.6	17.0											
17.7	15.7	14.1	20.0	11.9	5.1	0.6											
37.2	37.7	37.8	39.8	37.9	26.7	17.6											
					0.9	2.5	10.7	14.1	17.3	20.5	24.0	25.9	23.3				
			11.6	22.0	25.8	33.6	36.1	39.0	34.3	28.2	20.9	11.8	3.5				
			11.6	22.0	25.8	34.5	38.6	49.7	48.4	45.5	41.4	35.8	29.4				
37.2	37.7	49.4	61.8	63.7	61.2	56.2	49.7	48.4	45.5	41.4	35.8	29.4	24.9				

km. surface  
 goonumbla  
 6th May 1986

DISTANCE TRAVELLED BY HAUL TRUCKS  
 ON SURFACE  
 (km '000)

TABLE 2

PROJECT YEAR QUARTER	PIT TOTAL (km '000)	-2	-1	-1	-1	-1	1	1	1	1	2	2	2
		4	1	2	3	4	1	2	3	4	1	2	3
OPEN PIT MATERIAL		PPD E26N											
E26N Ore	120.0				5.4	7.4	6.5	6.8	7.1	6.6	5.3	6.5	6.4
E26N Waste	563.9	43.4	48.4	36.7	38.3	43.3	43.9	44.9	34.5	36.7	36.5	36.9	
E26N Sub-total	683.9	43.4	48.4	42.1	45.7	49.8	50.7	52.0	41.1	42.0	43.0	43.3	
E27 Ore	723.6												
E27 Waste	375.5												
E27 Sub-total	1099.1												
E22 Ore	407.6												
E22 Waste	306.4												
E22 Sub-total	714.0												
TOTAL IN-PIT	2497.0	43.4	48.4	42.1	45.7	49.8	50.7	52.0	41.1	42.0	43.0	43.3	

2	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6	6	7
4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1
PPD E27																	

5.7	6.9	6.2	7.6	7.5	5.8	5.3	5.7	5.7	5.6										
30.5	28.4	18.7	14.7	13.5	6.6	5.0	2.3	0.3	0.4										
36.2	35.3	24.9	22.3	21.0	12.4	10.3	8.0	6.0	6.0										
								8.0	47.0	53.9	48.9	47.5	47.0	45.5	48.1	47.3			
								9.1	28.5	38.7	37.6	34.3	25.2	26.6	27.4	18.8	21.6	18.9	17.2
								9.1	28.5	38.7	45.6	81.3	79.1	75.5	74.9	65.8	67.1	67.0	64.5

36.2	35.3	24.9	22.3	21.0	12.4	19.4	36.5	44.7	51.6	81.3	79.1	75.5	74.9	65.8	67.1	67.0	64.5
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

7	7	7	8	8	8	8	9	10	11	12	13	14	15
2	3	4	1	2	3	4	1-4	1-4	1-4	1-4	1-4	1-4	1
PPD E22													

51.0	55.1	55.8	43.2	53.2	41.2	30.9							
16.4	14.1	11.9	16.1	9.0	3.7	0.4							
67.4	69.2	67.7	59.3	62.2	44.9	31.3							
				5.5	16.3	57.1	57.1	57.1	57.1	57.1	55.4	44.9	
		15.6	29.5	34.7	45.1	48.4	45.0	34.7	25.1	16.5	8.5	2.3	1.0
		15.6	29.5	34.7	50.6	64.7	102.1	91.8	82.2	73.6	65.6	57.7	45.9
67.4	69.2	83.3	88.8	96.9	95.5	96.0	102.1	91.8	82.2	73.6	65.6	57.7	45.9

Blasting

D = depth of blast is constant 12.5 m.

A = area of blast. (refer to Table 3)

On a quarterly basis is set out in attached table. Also tabulated are the number of blasts/quarter.

Note: 62.5 operating days/quarter. Numbers of blasts required varies from 9-20 per quarter, i.e. one every 7 to 3 working days.

Number of blasts based on:

Ore blast  $2263 \text{ m}^2 = 50$  holes

Waste blast  $4253 \text{ m}^2 = 75$  holes

M = moisture content (to be advised)

In the range 0% - 10%

blast.drill  
goonubla  
6th May 1986

DUST EMISSION

AVERAGE AREA BLASTED - No. of BLASTS - No. of DRILL HOLES

TABLE 3

PROJECT YEAR QUARTER	UNITS	-2				-1				1				2			
		4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
OPEN PIT MATERIAL		PPD E26N															
Primary Ore	'000 sq.m	3.9 :															
Marginal Ore	'000 sq.m	0.6 :															
Oxidised Ore	'000 sq.m	17.0 18.3 :															
Waste	'000 sq.m	46.5	52.7	40.3	42.4	45.8	46.0	47.1	35.7	37.7	36.0	36.4	29.0				
E26N Sub-total	'000 sq.m	46.5	52.7	57.3	65.2	65.0	65.5	67.5	54.8	54.8	54.8	54.7	45.4				
	No of blasts	11	12	17	20	19	19	20	17	16	17	17	14				
	No of holes	820	929	1086	1251	1232	1242	1281	1052	1043	1050	1046	874				
Primary Ore	'000 sq.m																
Marginal Ore	'000 sq.m																
Oxidised Ore	'000 sq.m																
Waste	'000 sq.m																
E27 Sub-total	'000 sq.m																
	No of blasts																
	No of holes																
Primary Ore	'000 sq.m																
Marginal Ore	'000 sq.m																
Oxidised Ore	'000 sq.m																
Waste	'000 sq.m																
E22 Sub-total	'000 sq.m																
	No of blasts																
	No of holes																
TOTAL	'000 sq.m	46.5	52.7	57.3	65.2	65.0	65.5	67.5	54.8	54.8	54.8	54.7	45.4				
	No of blasts	11	12	17	20	19	19	20	17	16	17	17	14				
	No of holes	820	929	1086	1251	1232	1242	1281	1052	1043	1050	1046	874				

					PPD E27															
3	3	3	3	4	4	4	4	5	5	5	5	6	6	6	6	7				
1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1				
					PPD E27															
16.4	16.5	18.2	18.5	16.7	15.3	15.6	15.7	16.2												
3.6	1.2	3.7	3.1					0.6	0.8											
26.7	17.4	13.4	12.2	5.8	4.4	2.0	0.2	0.3												
46.7	35.1	35.3	33.8	22.5	19.7	18.2	16.7	16.5												
15	12	13	12	9	8	8	7	7												
913	698	720	692	471	416	393	368	363												
									2.6	15.0	17.2	15.6	15.2	15.0	14.6	15.4	15.1			
										1.9	0.6	3.2	2.2	2.4		2.2	0.9			
									0.6	12.3	5.4	12.8					0.9			
									8.5	18.1	35.3	27.6	32.5	25.0	23.9	25.3	16.2	21.2	16.1	15.1
									9.1	30.4	40.7	43.0	50.3	42.8	42.7	42.7	33.6	35.8	33.7	31.1
									2	10	11	13	16	14	14	14	11	11	12	11
									163	591	742	827	966	834	837	831	670	696	673	620
46.7	35.1	35.3	33.8	22.5	28.8	48.6	57.4	59.5	50.3	42.8	42.7	42.7	33.6	35.8	33.7	31.1				
15	12	13	12	9	10	18	18	20	16	14	14	14	11	11	12	11				
913	698	720	692	471	579	984	1110	1190	966	834	837	831	670	696	673	620				

7	7	7	8	8	8	8	9	10	11	12	13	14	15	
2	3	4	1	2	3	4	1-4	1-4	1-4	1-4	1-4	1-4	1	
PPD E22							:							

16.3	17.6	17.8	13.8	17.0	13.2	9.9							
1.6	2.1	2.1	1.8	1.9	0.8	0.1							
13.7	10.7	8.6	12.4	5.9	2.3	0.2							
31.6	30.4	28.5	28.0	24.8	16.3	10.2							
11	11	11	10	10	7	4							
637	624	591	563	522	350	224							
					1.5	4.5	15.8	15.8	15.8	15.8	15.8	15.3	12.4
						0.4	2.1	3.5	3.5	2.8	3.2	0.5	0.7
		5.5	6.4	7.8	4.3	4.6							
	15.0	22.6	27.8	36.9	42.8		33.4	27.2	17.0	10.7	3.5	1.3	0.1
	15.0	28.1	34.2	46.2	52.0		55.9	46.5	36.3	29.3	22.5	17.1	13.2
	4	8	9	13	14		18	15	13	11	9	7	6
	265	520	632	856	958		1086	906	726	600	482	372	291
31.6	30.4	43.5	56.1	59.0	62.5	62.2	55.9	46.5	36.3	29.3	22.5	17.1	13.2
11	11	15	18	19	20	18	18	15	13	11	9	7	6
637	624	856	1083	1154	1206	1182	1086	906	726	600	482	372	291

## Exposed Areas

### 1. Hard Rock Dumps

Refer to attached Table 4 showing surface area created quarterly.

Figure shown in actual surface area, i.e. allows for side slopes of 15° in case of waste dumps which will be rehabilitated and 38° for marginal ore and oxidised ore which may be processed.

Waste dumps are 20 m high. Swell 1.30. Marginal and oxidised ore dumps are 10 m high. Note M/O dumps for E22 and E27 are assumed to be at the pit site, not at crusher.

### 2. Open Pits

The full area/extent of each pit will be exposed from the end of the Pre-Production Development period (PPD).

E26N	exposed by	End Yr. - 1	18.5 ha
E27	exposed by	End 1st Quarter Yr. 5	14.5 ha
E22	exposed by	End Yr. 8	20.6 ha

NOTE PIT AREAS ARE NOT INCLUDED IN TABLE 4.

### 3. Topsoil

Assume 1 m of topsoil (T/S) stripped from beneath all dumps except T/S dumps.

T/S to be stacked 10 m high 38° side slopes, square dumps. Swell 1.30.

### 4. Overburden

Assume O/B dumps 10 m high. \* 38° square dumps. Swell 1.30

Topsoil derives from beneath:

- O/B dumps
- Waste dumps
- Marginal ore dumps
- Oxidised ore dumps
- Open pits.

Loading

All loading is done by rubber tyred front end loaders. Two estimates of emission are possible.

1. Loaders are scheduled to produce 6083t per shift.

From Year Quarter	To Year Quarter	No. of Loaders Operating	Production Rate/Shift
-1 - 1	3 - 1	2	12166
3 - 2	4 - 2	1	6083
4 - 3	6 - 1	2	12166
6 - 2	7 - 3	1	6083
7 - 4	10 - 4	2	12166
11 - 1	15 - 1	1	6083

USE ABOVE AS PEAK RATE

2. Alternatively use production schedule

62.5 days per quarter

3 shifts per day

6.5 hours production per shift.

See Table 5 for average loading rates and Table 6 for mine production schedule.

OPEN PIT	PROJECT YEAR QUARTER MATERIAL	UNITS	PIT TOTAL	PPD E26N											
				-2 4	-1 1	-1 2	-1 3	-1 4	1 1	1 2	1 3	1 4	2 1	2 2	
E26N	Marginal Ore	ha	5.92						0.12	0.18	0.46	0.83	0.56	0.23	0.51
	Oxidised Ore	ha	7.67				3.10	3.33	1.04	0.20					
	All T/S	ha	20.40	4.80	5.50	0.80	1.10	1.10	0.90	0.80	0.90	0.60	0.60	0.60	
	Overburden	ha	49.60	19.30	19.40	10.90									
	Waste	ha	66.56		5.36	6.07	4.64	4.88	5.27	5.29	5.43	4.11	4.34	4.14	
E26N	Cum Waste	ha	66.56		5.36	11.43	16.07	20.95	26.22	31.51	36.94	41.05	45.39	49.53	
	Cum. Other	ha	83.59	24.10	49.00	60.70	64.90	69.45	71.57	73.03	74.76	75.92	76.75	77.86	
E27	Marginal Ore	ha	4.52												
	Oxidised Ore	ha	5.93												
	All T/S	ha	14.40												
	Overburden	ha	40.30												
	Waste	ha	36.11												
E27	Cum Waste	ha	36.11												
	Cum. Other	ha	65.15												
E22	Marginal Ore	ha	11.19												
	Oxidised Ore	ha	5.38												
	All T/S	ha	23.80												
	Overburden	ha	77.80												
	Waste	ha	58.79												
E22	Cum. Other	ha	118.17												
	Cum Waste	ha	58.79												

PPD E27																			
2	2	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6	6	7	
3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	
0.48	0.06	0.69	0.23	0.70	0.59			0.12	0.16										
0.60	0.50	0.50	0.30	0.30	0.30	0.10	0.10												
4.19	3.35	3.07	2.00	1.55	1.40	0.67	0.51	0.23	0.02	0.04									
53.72	57.07	60.14	62.14	63.69	65.09	65.76	66.27	66.50	66.52	66.56									
78.94	79.50	80.69	81.22	82.22	83.11	83.21	83.31	83.43	83.59	83.59									
										0.36	0.12	0.60	0.42	0.46		0.41	0.18		
								0.10	2.28	1.01	2.37	0.17							
								4.10	4.50	0.70	0.80	0.60	0.40	0.50	0.50	0.30	0.30	0.30	
								21.00	15.50	3.80									
								0.96	2.05	4.00	3.13	3.68	2.83	2.70	2.87	1.84	2.41	1.82	1.71
								0.96	3.01	7.01	10.14	13.82	16.65	19.35	22.22	24.06	26.47	28.29	30.00
								25.20	47.48	52.99	56.16	57.29	57.81	58.91	59.83	60.59	60.89	61.60	62.08

7	7	7	8	8	8	8	9	10	11	12	13	14	15
2	3	4	1	2	3	4							1

PPD E22

0.30 0.40 0.40 0.34 0.36 0.15 0.02

0.30 0.20 0.20 0.20 0.10 0.10

1.55 1.21 0.98 1.41 0.67 0.26 0.03

31.55 32.76 33.74 35.15 35.82 36.08 36.11  
 62.68 63.28 63.88 64.42 64.88 65.13 65.15

0.07 1.47 2.50 2.50 1.94 2.25 0.34 0.12

6.80 6.80 0.20 1.03 1.21 1.47 0.81 0.86  
 24.60 25.90 27.30 0.50 0.60 0.80 0.80 2.40 2.00 1.40 0.90 0.50 0.10

1.70 2.57 3.15 4.19 4.86 15.17 12.34 7.72 4.88 1.61 0.59 0.01

0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00  
 1.70 4.27 7.42 11.61 16.47 31.64 43.98 51.70 56.58 58.19 58.78 58.79

PROJECT YEAR QUARTER	MATERIAL	UNITS	PPD E26N				PPD E27												
			-2 4	-1 1	-1 2	-1 3	-1 4	1 1	1 2	1 3	1 4	2 1	2 2	2 3	2 4				
OPEN PIT	Primary Ore	t/hr																	
	Marginal Ore	t/hr																	
	Oxidised Ore	t/hr																	
	Waste	t/hr																	
E26N	Sub-total	t/hr t/shift																	
	Primary Ore	t/hr																	
	Marginal Ore	t/hr																	
	Oxidised Ore	t/hr																	
	Waste	t/hr																	
E27	Sub-total	t/hr t/shift																	
	Primary Ore	t/hr																	
	Marginal Ore	t/hr																	
	Oxidised Ore	t/hr																	
	Waste	t/hr																	
E22	Sub-total	t/hr t/shift																	
TOTAL		t/hr t/shift																	

					PPD E27														
3 1	3 2	3 3	3 4	4 1	4 2	4 3	4 4	5 1	5 2	5 3	5 4	6 1	6 2	6 3	6 4	7 1			
433	437	482	491	441	405	414	415	429											
96	33	98	82			16	22												
706	459	355	322	153	117	53	6	8											
1235	929	935	895	594	522	483	443	437											
8028	6039	6078	5818	3861	3393	3140	2880	2841											
								70	410	471	427	415	410	398	420	414			
									52	17	86	60	66		59	25			
					15	326	144	338	25										
					231	495	964	756	889	683	652	693	444	580	440	413			
					246	821	1108	1164	1376	1171	1165	1168	920	978	919	852			
					1599	5337	7202	7566	8944	7612	7573	7592	5980	6357	5974	5538			
1235	929	935	895	594	768	1304	1551	1601	1376	1171	1165	1168	920	978	919	852			
8028	6039	6078	5818	3861	4992	8477	10082	10407	8944	7612	7573	7592	5980	6357	5974	5538			

7	7	7	8	8	8	8	9	10	11	12	13	14	15
2	3	4	1	2	3	4	1-4	1-4	1-4	1-4	1-4	1-4	1
PPD		E22											

446	482	487	377	464	360	270								
43	57	58	48	53	22	2								
374	292	235	340	162	63	7								
863	831	780	765	679	445	279								
5610	5402	5070	4973	4414	2893	1814								
					41	123	:	431	431	431	431	431	417	339
						11	:	57	97	97	75	87	13	18
			140	164	200	110	:	29						
	410	619	759	1010	1172		:	915	744	465	294	97	36	2
							:							
	410	759	923	1251	1416		:	1432	1272	993	800	615	466	359
	2665	4934	6000	8132	9204		:	9308	8268	6455	5200	3998	3029	2334
							:							
863	831	1190	1524	1602	1696	1695	:	1432	1272	993	800	615	466	359
5610	5402	7735	9907	10414	11025	11018	:	9308	8268	6455	5200	3998	3029	2334

5th. February, 1986  
mine.sched

TABLE 6

GROUNDWORK OPEN  
MINE PRODUCTION S

OPEN PIT	PROJECT YEAR QUARTER	MATERIAL	UNITS	PIT TOTAL	PPD E26N										
					-2 4	-1 1	-1 2	-1 3	-1 4	1 1	1 2	1 3	1 4	2 1	2 2
E26N	Primary Ore	kt		8956					127	408	515	516	518	513	518
	Marginal Ore	kt		1008					20	30	79	141	96	40	87
	Oxidised Ore	kt		1238			500	537		168	33				
	Waste	kt		18642	1500	1700	1300	1367		1477	1483	1520	1152	1215	1161
	Total Hard Rock	kt		29844	1500	1700	1800	2051		2083	2110	2177	1766	1768	1766
E27	Overburden	kt		7781	3075	3075	1631								
		kbc#		3796	1500	1500	796								
E22	Primary Ore	kt		7706											
	Marginal Ore	kt		793											
	Oxidised Ore	kt		1032											
	Waste	kt		10617											
	Total Hard Rock	kt		20148											
E22	Overburden	kt		6309											
		kbc#		3078											
TOTAL	Primary Ore	kt		13147											
	Marginal Ore	kt		2116											
	Oxidised Ore	kt		892											
	Waste	kt		17277											
	Total Hard Rock	kt		33432											
TOTAL	Overburden	kt		12100											
		kbc#		5902											
TOTAL	PRIMARY ORE			29809					127	408	515	516	518	513	518
	MARGINAL ORE			3917					20	30	79	141	96	40	87
	OXIDISED ORE			3162			500	537		168	33				
	WASTE			46536	1500	1700	1300	1367		1477	1483	1520	1152	1215	1161
	TOTAL HARD ROCK	kt		83424	1500	1700	1800	2051		2083	2110	2177	1766	1768	1766
TOTAL	OVERBURDEN	kt		26190	3075	3075	1631								
		kbc#		12776	1500	1500	796								
Annual Hard Rock									7051			8136			

P I T S  
C H E D U L E

2	2	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6	6
3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
							: PPD E27 :										
511	520	528	532	588	598	538	493	504	506	523							
81	10	117	40	120	100			20	27								
1174	937	860	560	433	392	187	143	64	7	10							
1766	1467	1505	1132	1141	1090	725	636	588	540	533							

							: 85 :				500	574	521	506	500	485	512				
							:				63	21	105	73	81		72				
							:				18	397	175	412	30						
							:				282	603	1175	921	1083	832	795	844	541	707	536
							:				300	1000	1350	1418	1676	1427	1421	1423	1122	1192	1120
							:				3280	2460	569								
							:				1600	1200	278								

511	520	528	532	588	598	538	493	504	506	608	500	574	521	506	500	485	512					
81	10	117	40	120	100			20	27		63	21	105	73	81		72					
1174	937	860	560	433	392	187	425	667	1182	931	1083	832	795	844	541	707	536					
1766	1467	1505	1132	1141	1090	725	936	1588	1890	1951	1676	1427	1421	1423	1122	1192	1120					
							3280				2460	569										
							1600				1200	278										
6767							4868				5139				6475				4857			

TABLE 3.15-1

7 1	7 2	7 3	7 4	8 1	8 2	8 3	8 4	9	10	11	12	13	14	15 1		
PPD E22																
504	544	587	594	460	566	439	329									
31	53	70	71	59	64	27	3									
503	456	356	287	414	197	77	8									
1038	1053	1013	952	933	827	543	340									
								50	150	2100	2100	2100	2100	2100	2034	413
									13	278	472	473	367	426	65	22
				171	200	244	134			143						
		500	754	925	1231	1428				4459	3628	2268	1433	474	174	3
		500	925	1125	1525	1725				6980	6200	4841	3900	3000	2273	438
	3900	4100	4100													
	1902	2000	2000													
504	544	587	594	460	566	489	479	2100	2100	2100	2100	2100	2034	413		
31	53	70	71	59	64	27	16	278	472	473	367	426	65	22		
				171	200	244	134	143								
503	456	356	787	1168	1122	1308	1436	4459	3628	2268	1433	474	174	3		
1038	1053	1013	1452	1858	1952	2068	2065	6980	6200	4841	3900	3000	2273	438		
	3900	4100	4100													
	1902	2000	2000													
			4556					7943	6980	6200	4841	3900	3000	2273	438	

## DRILLING

Emission rate given as 0.6 kg/hole.

### Drills in operation

Production Drills - 250 mm  $\phi$

In years 1, 8, 9, 10, maximum number of drills operating is two (2). In other years only one (1).

Final Wall Drill - 140 mm  $\phi$

One (1) drill only

Cable Bolting Drill - 88 mm  $\phi$

One (1) drill only.

Therefore maximum possible emission rate is that of four (4) drills in years 1, 8, 9, 10. In other years maximum emission is from three (3) drills.

Note that Final Wall Drill and Cable Bolt Drill are much smaller than the Production Drill.

If emission is based on number of holes, this can be calculated from the approximate number of blasts (see Blasting - Table 3).

Note Table 3 does not include Cable Bolt drill holes.

Alternatively if emission is calculated from number of drills can assume:

Production Drill	-	4.47 hrs drilling/shifts of 8 hours
Final Wall Drill	-	4.47 hrs drilling/shift
Cable Bolt Drill	-	3.93 hrs drilling/shift

Cable bolting requires from 750-3000 holes drilled/yr., i.e. average 3-12 holes/day. Normal practise would be for the drill to operate for a full shift as required. Therefore expect the peak rate to be 10-12 holes per day on a 1 shift basis.

THIS NUMBER TO BE ADDED TO TABLE 3 NUMBERS.

Truck Dumping

Dump Locations

Ore - at open pit crusher dump or into crusher.

Waste - alongside open pits.

Marginal and oxidised ore - close by open pits

Topsoil and overburden - close by open pits

Calculate dumping rates from Total Hard Rock component shown in Mine Production Schedule Table 6.

For average rates use:

62.5 days/quarter

3 shifts/day

6.5 effective hours per shift.

Note (1) Overburden in Table 6 only includes T/S from open pits. For total T/S volumes see Table 7.

(2) All T/S and O/B to be moved by scrapers.

For Peak Rates say average \* 1.15.





## SCRAPERS

Peak period for scrapers is during PPD for each pit, when T/S and O/B has to be stripped.

Assuming a major contractor employs Cat 657E scrapers (tandem powered push pull), the numbers required to operate are shown in Table 8. Calculation assumes average on-surface haul (one-way) of 1500 m plus average in-pit haul of 200 m level and 250 m on grade of +10%.

At other times typically one (1) 631 D scraper operating 1 shift 5 days/week can handle other requirements.

JOB No: 600um5/a.

DATE: 9/5/86.

No. of Operating Scrapers (657E) Required

TABLE 8.

YEAR		-2	-1	-1	TYPICAL	4	4	4	TYPICAL	7	7	7	TYPICAL
QUARTER		4	1	2	QUARTER	2	3	4	QUARTER	2	3	4	
E26N	kbcm.	1744	1795	854	60								
	scraper No	8	9	+									
E27	kbcm					1809	1440	326	45				
	Scraper No					9	7	2					
E22	kbcm									2283	2381	2016	55
	scraper No									11	11	10	

Note: ① Except during PPD periods noted the typical amount to be moved per quarter could be handled by one smaller scraper (say 631D 237 m<sup>3</sup> heaped capacity) operating 1 shift/day.

② Above table assumes 6 days/week 3 shifts/day 6.5 hrs effective/shift.

**APPENDIX 2**

Wind speed-direction-stability analysis



VARIATION IN STABILITY CATEGORY WITH WIND DIRECTION AND WIND SPEED (KNOTS)

		WIND DIRECTION																	
		CALM	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	TOTAL
8-12	A	0.0% 0	4.2% 15	6.4% 23	11.9% 50	3.0% 11	0.0% 0	.7% 1	1.8% 4	.7% 3	1.8% 9	2.3% 11	2.9% 11	1.6% 4	2.2% 5	3.8% 5	0.0% 0	6.5% 13	3.1% 165
8-12	B	0.0% 0	5.3% 19	2.5% 9	7.1% 30	3.0% 11	.6% 1	2.2% 3	.4% 1	1.1% 5	2.8% 14	3.4% 16	5.6% 21	5.5% 14	8.5% 19	6.9% 9	4.7% 7	7.5% 15	3.7% 194
8-12	C	0.0% 0	8.9% 32	8.0% 29	4.5% 19	6.7% 25	6.9% 12	4.3% 6	2.2% 5	2.1% 9	7.2% 36	9.1% 43	10.1% 38	10.2% 26	11.6% 26	7.7% 10	10.7% 16	9.5% 19	6.7% 351
8-12	D	0.0% 0	16.6% 60	6.4% 23	2.4% 10	13.7% 51	4.0% 7	7.2% 10	4.4% 10	3.0% 13	7.2% 36	10.2% 48	10.3% 39	10.6% 27	10.3% 23	4.6% 6	7.3% 11	10.0% 20	7.5% 394
8-12	E	0.0% 0	2.5% 9	3.6% 13	.7% 3	.5% 2	2.3% 4	0.0% 0	.4% 1	1.6% 7	1.0% 5	1.1% 5	.3% 1	.4% 1	.9% 2	0.0% 0	1.3% 2	2.0% 4	1.1% 59
8-12	F	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
8-12	G	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
>12	A	0.0% 0	.6% 2	1.4% 5	.5% 2	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	.2% 1	0.0% 0	.5% 2	0.0% 0	0.0% 0	0.0% 0	1.3% 2	.5% 1	.3% 15
>12	B	0.0% 0	.3% 1	0.0% 0	0.0% 0	.3% 1	0.0% 0	.7% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	.4% 1	0.0% 0	0.0% 0	1.0% 2	.1% 6
>12	C	0.0% 0	1.7% 6	1.1% 4	1.2% 5	.5% 2	0.0% 0	0.0% 0	0.0% 0	0.0% 0	.4% 2	.4% 2	2.4% 9	1.6% 4	.4% 1	1.5% 2	2.7% 4	2.0% 4	.9% 45
>12	D	0.0% 0	7.2% 26	2.2% 8	.5% 2	2.2% 8	0.0% 0	0.0% 0	.4% 1	1.6% 7	.8% 4	2.1% 10	.5% 2	.8% 2	1.3% 3	1.5% 2	3.3% 5	3.5% 7	1.7% 87
>12	E	0.0% 0	1.1% 4	.6% 2	.5% 2	.8% 3	0.0% 0	0.0% 0	1.3% 3	.5% 2	.2% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	.3% 17
>12	F	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	.7% 1	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	.0% 1
>12	G	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0	0.0% 0
T O T A L		100.0% 451	100.0% 361	100.0% 362	100.0% 421	100.0% 372	100.0% 175	100.0% 139	100.0% 226	100.0% 437	100.0% 501	100.0% 471	100.0% 378	100.0% 255	100.0% 224	100.0% 130	100.0% 150	100.0% 200	100.0% 5253

NUMBER OF NO-DATAS 1033

### APPENDIX 3

#### TOTAL DUST MASS FACTORS

Evaluation of Equation (2) requires knowledge of the definite integral

$$I = \int_0^{\infty} \exp[-cx^b] dx$$

This integral can be evaluated by changing the variable to

$$y = cx^b$$

whence

$$I = \frac{1}{bc^{1/b}} \int_0^{\infty} y^{(1/b)-1} \cdot \exp[-y] dy$$

$$= \Gamma(1/b) / bc^{1/b}$$

where  $\Gamma$  represents the gamma function. Table A3.1 provides values of the requisite gamma functions.

**TABLE A3.1**  
VALUES OF REQUISITE GAMMA FUNCTIONS

Stability Class	b	1/b	$\Gamma(1/b)$
A	0.14	7.14	936.4
B	0.15	6.67	391.4
C	0.18	5.56	57.7
D	0.30	3.33	2.8
E	0.30	3.33	2.8
F	0.40	2.50	1.3

**APPENDIX 4**

Fortran program to evaluate dust concentration

```
1 C PROGRAM DUSTCON (C) 1986 Natural Systems Research Pty. Ltd.
2 C This program is designed to give approximate dust loadings on the
3 C basis of total annual dust emissions (based on SPCC emission factors)
4 C and allocated on the basis of wind correlation analysis from the
5 C NSR standard output that handles stability-category/wind direction/speed
6 C produced by program STABC3
7
8 c 2 June 1986 revision made when it was realised that all the source
9 c depletion functions could be integrated in terms of gamma functions
10
11 c 4 wind speed classes used
12
13
14 dimension wsc(4),aexp(7),bexp(7),ff(28)
15 dimension ii(17,28),dust(16,28)
16 dimension smma(7)
17
18 character*8 dnam(16)
19 character outnam*20
20
21 data dnam/'NNE','NE','ENE','E','ESE','SE','SSE',
22 * / 'S','SSW','SW','WSW','W','WNW','NW','NNW','N'
23 * /
24
25
26 c wind speed classes are in knots
27
28
29 data wsc/3.0,5.5,10.0,12.0/
30
31
32 data aexp/0.120,0.135,0.183,0.115,0.160,0.114,0.114/
33 data bexp/0.14,0.15,0.18,0.30,0.30,0.40,0.40/
34
35 data smma/936.41,391.4,57.7,2.77,2.77,1.33,1.33/
36
37 c
38 fact=0.514791
39
40 C 1 knot = 0.514791 m/s
41
42 pi=3.1416
43
44
45
46 c
47 c the annual dust loading is tandl(3849.6 tonnes in max year)
48
49 tandl=3849.6
50
51 c the total number of wind occurrences is 5253
52 c based on the wind correlation analysis output.
53
54 totwnd=5253.
55 unnt=tandl/totwnd
56
```

```
57
58 c      vd is the settling velocity. We follow advice and
59 c      use 5cm/s unless known otherwise
60
61          vd=5
62
63 c
64 c      now read in the values from wind.dat
65
66
67 c
68 c      call offile(9,outnam,1,'output file ->',14)
69
70          open(7,file='wind4.dat')
71          read(7,301)ii
72
73 c      format for wind.dat is two header lines,
74 301      format(//,28(i6(i2,1x),i3,//))
75 c
76 c      now we set the exponential factors
77 c
78          do 101 i=1,28
79
80              sum=0
81                  iwr=((i-1)/7)
82                  irem=i-7*iwr
83                  xxxx=aexp(irem)*vd/(fact*wsc(iwr+1))
84                  ym=bexp(irem)
85                  rym=1./ym
86                  ff(i)=gamma(irem)/(ym*xxxx**rym)
87                  write(9,312) i,irem,iwr,xxxx,ym,ff(i)
88                  ff(i)=unnt/ff(i)
89
90
91
92 c      column 17 in ii(17,i) is the sum of all directions
93 c      for one stability and one speed class.
94
95 101      continue
96 312      format(3i5,1e3e10.2)
97
98 c      now sum the dust at 100m intervals out to 10km
99
100          do 112 j=1,16
101              do 113 k=1,101
102                  x=(k-1)*100.
103                  sum=0
104
105                  do 114 i=1,28
106
107                      tdust=ii(j,i)
108
109
110                      iwr=((i-1)/7)
111
112
```

```

113
114      irem=i-7*iwr
115      tprt=x**(bexp(irem))
116      expr=-aexp(irem)*vd*tprt/(fact*wsc(iwr+1))
117      xpr=exp(expr)*tdust*ff(i)
118  c
119  c      units at the moment are tonnes per metre per year
120  c      a=(2.*pi/16.)*x
121      xpr=xpr/a
122      xpr=xpr/12.
123      xpr=xpr*1.0e6
124  c      for reference calculate the dust conc for each category at
125  c      2km.      (k=10 when interval set to 200m)
126  c      k=21 when set to 100m and k-1
127      if (k.ne.21) goto 200
128      tprt2=vd/(fact*wsc(iwr+1))
129      tphi=aexp(irem)*tprt*tprt2
130      tephi=exp(-tphi)
131      tprt3=unnt/ff(i)
132      tprt4=tephi/tprt3
133      tprt5=unnt*1.0e6/(12.*a)
134      tprt6=ii(j,i)*tprt4*tprt5
135      if(k.eq.21.and.j.eq.5)write(*,333)ii(j,i),aexp(irem),tprt,tprt2,
136  *      tphi,tephi,tprt3,tprt4,tprt5,tprt6,xpr
137
138 333      format(i4,5f8.3,1e5c9.2)
139
140
141      if(k.eq.21)dust(j,i)=xpr
142 200      continue
143      sum=sum+xpr
144 114      continue
145      write(9,331)x,dnam(j),sum
146 113      continue
147 112      continue
148      write(9,337)dust
149 337      format('Dust conc. results at 2km.',/29(1e16e8.2,/))
150
151 331      format(0pf8.0,'m.',a5,1pe10.2)
152      end
153

```

**APPENDIX J**

**DUST GAUGE SITING**

Natural Systems Research Pty. Ltd.

PARKES JOINT VENTURE  
GOONUMBLA PROJECT  
DUST GAUGE SITING

Prepared by : Natural Systems Research Pty. Ltd.  
25 Burwood Road  
HAWTHORN Vic. 3122

For : Parkes Joint Venture

Date : December 1985

Report : CR 312/1  
WP 1458B/0106B

(i)

CONTENTS

		<u>Page</u>
1.0	INTRODUCTION	1
	1.1 Dust	1
	1.2 Objectives of Dust Measurement Programme	1
2.0	DUST DEPOSITION	3
	2.1 Previous Studies	3
	2.2 Data to Date	3
3.0	CLIMATOLOGY	5
4.0	RECOMMENDATIONS	10
5.0	REFERENCES	13

FIGURES

1. Air quality sampling sites
  2. Source depletion factors for particulates (from PEDCO, 1978)
  3. Three hourly wind roses
  4. Monthly wind roses
  5. Seasonal wind roses
  6. Annual wind rose
  7. Recommended future dust sampler locations
- Insert: Wind transport overlay

## 1.0 INTRODUCTION

Peko-Wallsend Operations Ltd., on behalf of the Joint Venture Partners, are presently exploring an area of copper mineralization under licence near Parkes in Central New South Wales.

Environmental studies related to proposed open pit mining activity commenced in November 1981 and have continued to the present. The environmental studies were designed to provide baseline environmental data for:

- (i) The eventual preparation of a Draft Environmental Impact Statement.
- (ii) A management programme should the development proceed.

### 1.1 Dust

One of the objectives in the design of the original monitoring programme was the establishment of background dust levels in the area. To this end twelve dust deposition gauges were situated around the site at distances that ranged from 3 km to 17 km from the proposed mine site. The sites of these gauges are depicted in Figure 1 and their locations are understood to reflect proximity to a range of different dust sources.

For the EIS, it may be a requirement that predictive mathematical dust dispersion modelling be carried out. This is a mainly theoretical exercise based on literature values for dust generation for given minesite activities, with predictions based on site wind data calibrated by measured results from a comparable location elsewhere.

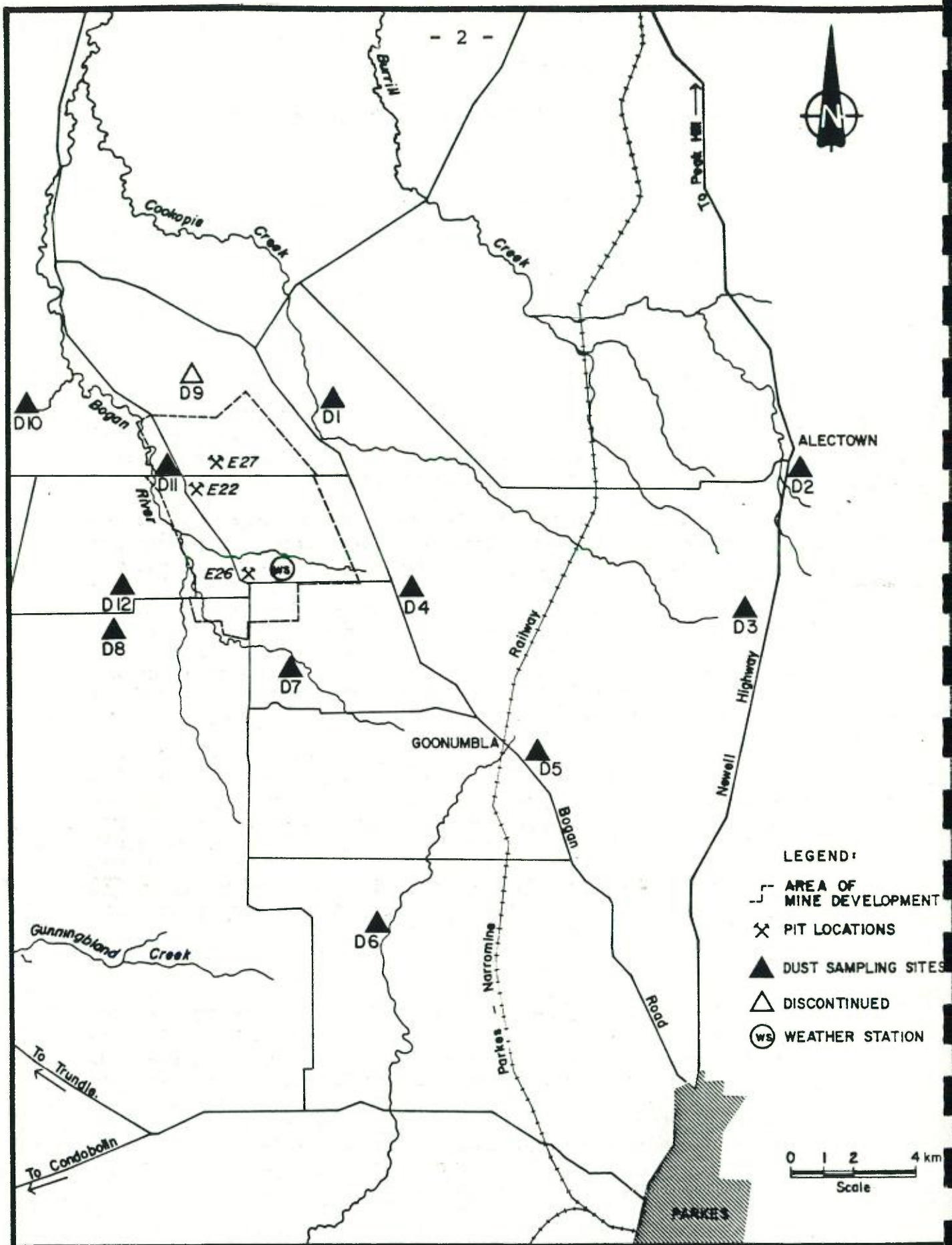
The existing program characterizes background dust from various sources. For purposes of predictive modelling during the EIS phase, background levels in likely zones of mine dust deposition are required. Looking further ahead to the operational phase, EIS predictions will require monitoring, and for this purpose, an "insurance policy" pre-mining baseline is required.

We have therefore reviewed the location of dust gauges and recommended changes that will meet these two requirements.

### 1.2 Objectives of Dust Measurement Programme

To provide background dust fallout data which can subsequently be used to:

- (i) Identify future mine produced fugitive dust in terms of its increment over known background levels.
- (ii) Calibrate and validate any future mathematical dust prediction model.



Natural Systems Research Pty. Ltd.  
Environmental Consultants

PARKES JOINT VENTURE

GOONUMBLA PROJECT

## AIR QUALITY SAMPLING SITES PARKES REGION

Compiled by: TB

Date: DEC. 1985

Figure 1

## 2.0 DUST DEPOSITION

The factors that influence fugitive dust deposition include:

- the nature of the mining activity.
- the density and size distribution of particulates.
- the wind speed and direction.
- atmospheric stability.
- antecedent precipitation.

### 2.1 Previous Studies

The majority of work on fugitive dust emissions from working mines consists of coal mining studies. PEDCO (1978) produced a survey of fugitive dust from five different Western U.S. surface mines and their resulting unit emission factors have been used by the SPCC.

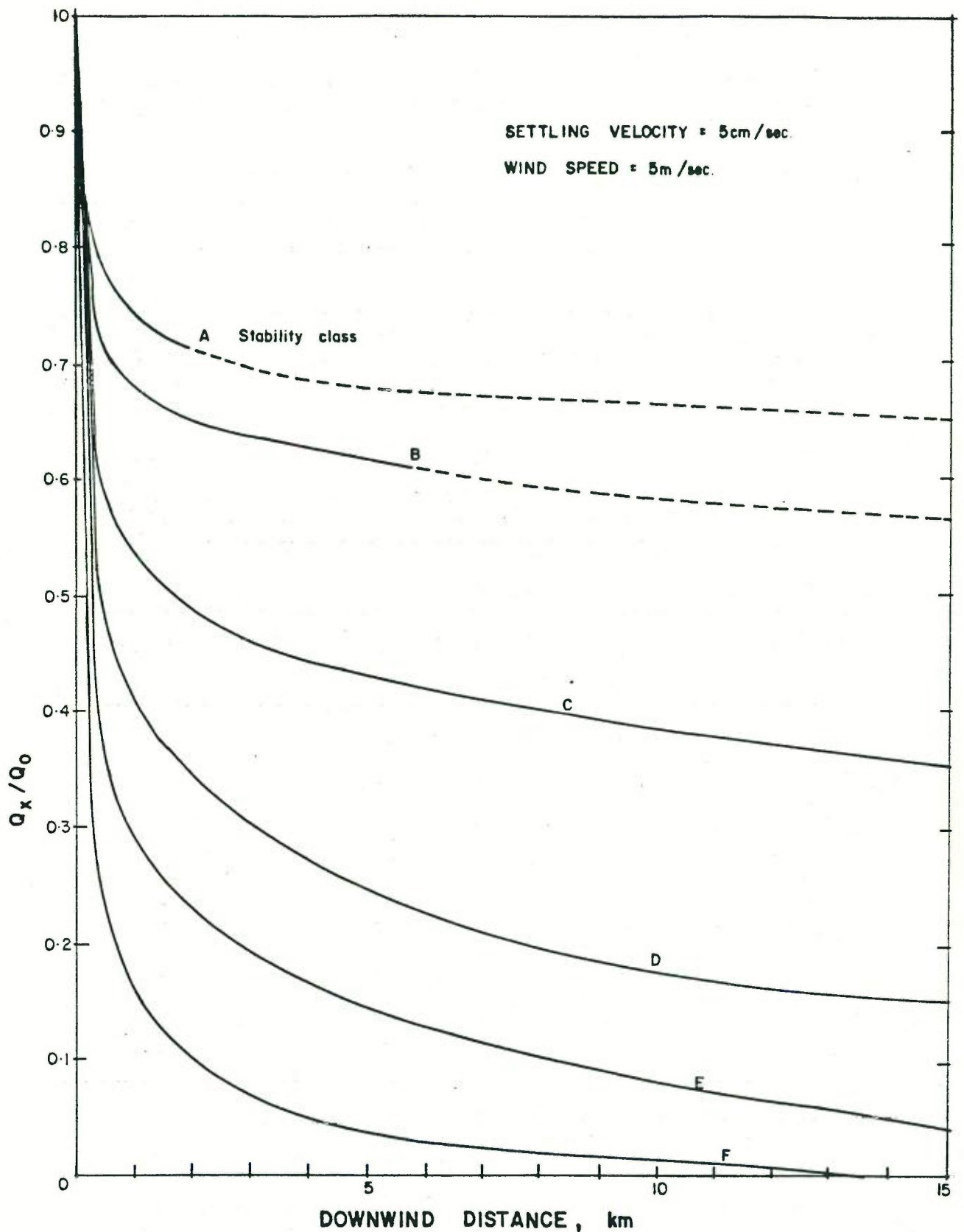
PEDCO (1978) present a graph of source depletion factors as a function of atmospheric stability class for ground level sources. Their curves for a wind speed of 5m/s and a settling velocity of 5cm/s are reproduced in Figure 2. This settling velocity corresponds to a particle size between 25 microns (for specific gravity 2.6) and 29 micron (for specific gravity 2.0). Atmospheric stability class D corresponds to neutral stability and is the one that generally occurs most frequently. For a neutral stability class and an average wind speed of 5m/s the curves of Figure 2 predict that about 40 percent of initial emissions would remain in suspension 1 km downwind and about 17 percent at 10km.

The PEDCO (1978) results are theoretically based. Observations from the dust deposition gauges situated around the Bayswater Colliery (NSR 1983) indicated that dust generated by mining activity was mostly deposited within a few kilometres of the mine. Experience at Lemington Mine (J.A. Crosdale, pers. comm.) indicates a decline in dust deposition out to 3km and then an increase further out attributed to agricultural activity. At Woodlawn Mines (P. Southern, pers. comm.) the majority of dust settles within 500m of the pit, and mine-derived fugitive dust appears to be negligible 1km from the mine.

### 2.2 Data to Date

Monthly dust data from dust deposition gauges around the PJV site have been collected on a monthly basis from May 1982 to June 1985. The collections have been analysed for total dust (presented as g/m<sup>2</sup>/month) and as residual material, the latter being that remaining after ashing at 450 degrees Celsius for 4 hours to remove organic matter.

Dust data have been tabulated in reports on environmental monitoring and are discussed in the summary report for the period November 1981 to December 1984 (Croft & Associates, 1985).



Source: PEDCO (1978)



Natural Systems Research Pty Ltd  
Environmental Consultants

PARKES JOINT VENTURE

GOONUMBLA PROJECT

SOURCE DEPLETION  
FACTORS

Drawing No. 312

Date, 6 December 1985

Figure 2

### 3.0 CLIMATOLOGY

Figures 3 to 6 comprise three-hourly, monthly, seasonal and annual wind roses based on the wind data collected from the weather station depicted on Figure 1.

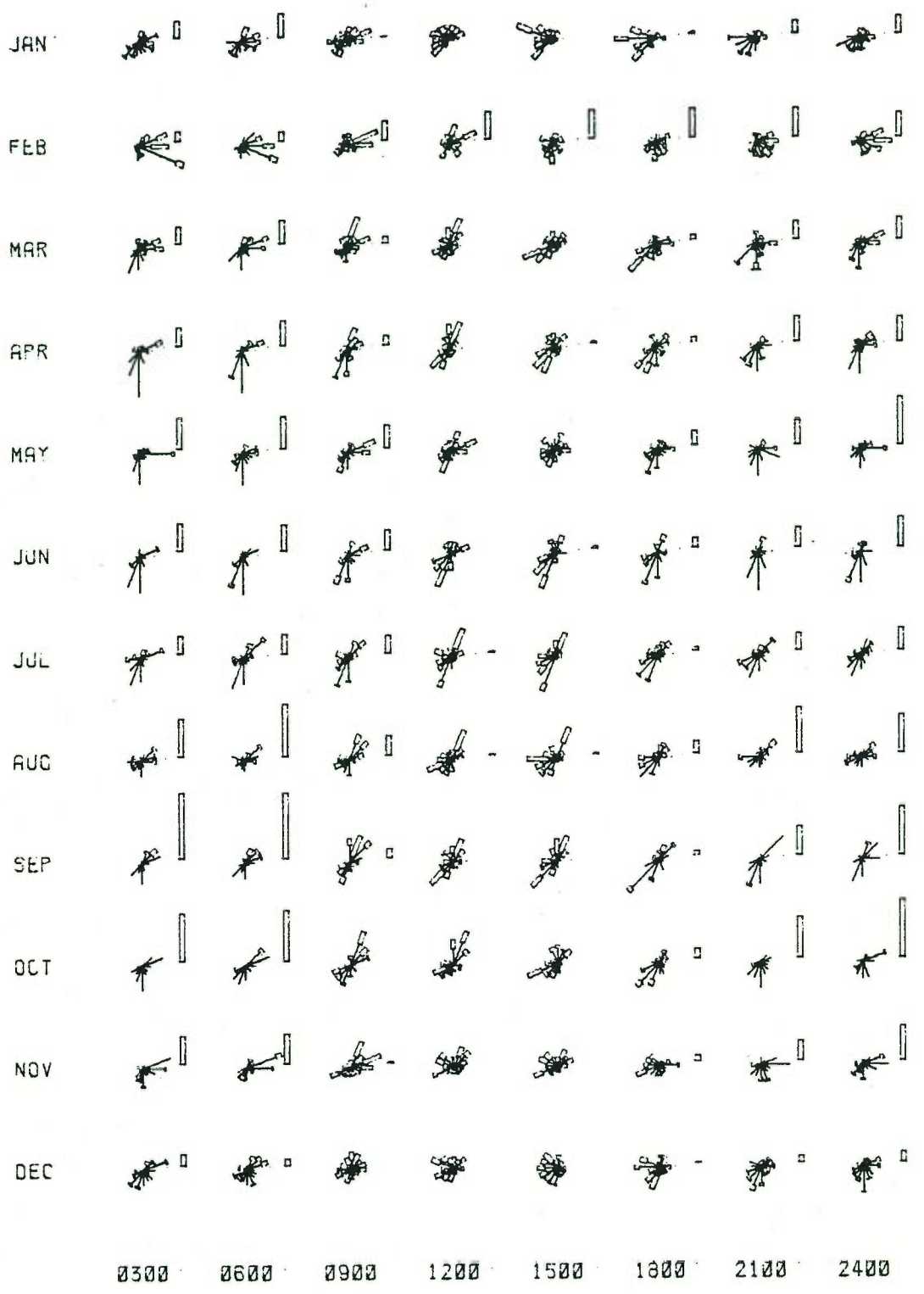
The annual wind rose indicates that prevailing winds are north-easterlies and south-westerlies. Most of the winds have speeds less than 4m/s, and the occasional very strong wind (greater than 10m/s) occurs primarily from the southern quarter, with an isolated strong northerly also included in the data set.

Rainfall data for Parkes P.O. (Station 065026) are given in Table 1. The data show no seasonality and there is unlikely to be any strong correlation between rainfall, which would act as a dust suppressant, and wind. Thus the wind climatology based on the annual wind rose can be used to determine optimum dust gauge siting.

TABLE 1  
RAINFALL CLIMATOLOGY (PARKES P.O.)

	Rainfall (mm)		Number of Raindays
	Mean	Median	Mean
January	57	43	5
February	46	29	5
March	47	36	5
April	40	28	5
May	45	36	7
June	52	43	10
July	47	44	10
August	49	47	9
September	39	32	7
October	50	41	8
November	45	35	6
December	52	43	5
Year	569	532	82

Source: Bureau of Meteorology



SPEED (m/s) <4 4-10 >10 FREQUENCY (%) 50% CALM

BASED ON HOURLY DATA AVERAGED EITHER SIDE AND ON THE HOUR

**NR** Natural Systems Research Pty Ltd  
Environmental Consultants

PARKES JOINT VENTURE

GOONUMBLA PROJECT

GOONUMBLA N.S.W.  
AVERAGE THREE HOURLY  
WIND ROSES FOR EACH MONTH  
DECEMBER 1982 - FEBRUARY 1985

Drawing No. 312  
Date: 5 December 1995

Figure 3

JAN

FEB

MAR



APR

MAY

JUN



JUL

AUG

SEP



OCT

NOV

DEC



SPEED (m/s) <4 4-10 >10

FREQUENCY (%) 50% CALM

BASED ON HOURLY DATA



Natural Systems Research Pty Ltd  
Environmental Consultants

PARKES JOINT VENTURE

GOONUMBLA PROJECT

GOONUMBLA N. S. W.

MONTHLY

WIND ROSES

DECEMBER 1982 - FEBRUARY 1985

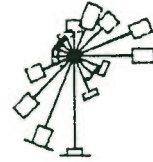
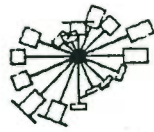
Drawing No: 312.

Date: 5 December 1985

Figure 4

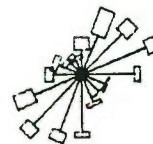
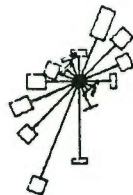
SUMMER

AUTUMN



WINTER

SPRING



SPEED (m/s) <4 4-10 >10

FREQUENCY (%) 0 30% CALM

BASED ON HOURLY DATA



Natural Systems Research Pty Ltd  
Environmental Consultants

PARKES JOINT VENTURE

GOONUMBLA PROJECT

GOONUMBLA N. S. W.

SEASONAL

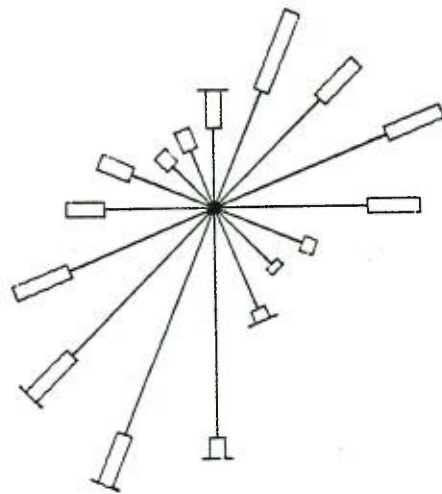
WIND ROSES

DECEMBER 1982 - FEBRUARY 1985

Drawing No. 312

Date: 5 December 1995

Figure 5



SPEED (m/s)    <4    4-10    >10    FREQUENCY (%)    10%    CALM

BASED ON HOURLY DATA



Natural Systems Research Pty Ltd  
Environmental Consultants

PARKES JOINT VENTURE

GOONUMBLA PROJECT

GOONUMBLA N. S. W.  
ANNUAL  
WIND ROSE  
DECEMBER 1982 - FEBRUARY 1985

Drawing No. 312

Figure 6

#### 4.0 RECOMMENDATIONS

The existing data are sufficient to provide an overall baseline of regional agricultural activity. Future dust investigation will need to concentrate on site specific data for near field baseline results with which to identify mine derived increases that may form the basis of future compensation claims.

Identification of mine derived dust is most readily accomplished by dust gauges situated downwind from dominant dust sources so that the distance dependence of collected dust can be determined.

It is assumed that mining activity will concentrate at E22, E26 and E27. The line joining E22 and E27 aligns NE-SW. As the dominant direction in which strong winds blow is NE to NNE, a succession of gauges have been positioned along this line:

- . ND12 (identical to the existing D12)
- . ND13
- . ND14 and
- . ND15

Gauges relevant to E26 are:

- . ND9 (1 km NNE)
- . ND2 (NNE on boundary of mine area)
- . ND3 (NE on boundary of mine area)
- . ND8 (WSW on boundary)
- . ND6 (SSW on boundary)
- . ND1 (identical to the present D1) which is NNE from E26 and provides a long term gauge with which to link the previous and new collectors.

ND10 is positioned at the centroid of the three pits and ND11 (the same as the previous D11) is positioned NW of the centroid with ND9 in the corresponding position SE.

ND16 and ND6 are positioned on the boundary north and south of the centroid respectively.

It is proposed that D7 continue (as ND7) to provide further continuity with the long term data set and to act as a southern collector situated off the boundary, with ND5 situated on the boundary between ND7 and E26.

In order to complete adequate coverage of the boundary it is proposed that D4 be moved in to the eastward extremity of the boundary.

To assist in interpreting the rationale for the dust gauge siting, a wind transport diagram is included in the back of the report as a transparency to be overlaid on the relevant dust source of Figure 7. The wind transport diagram consists of the wind rose rotated by 180°. The rotation is necessary because the wind rose indicates the direction from which the wind has come whereas interest in relation to dust deposition centres on the direction to which the wind blows.

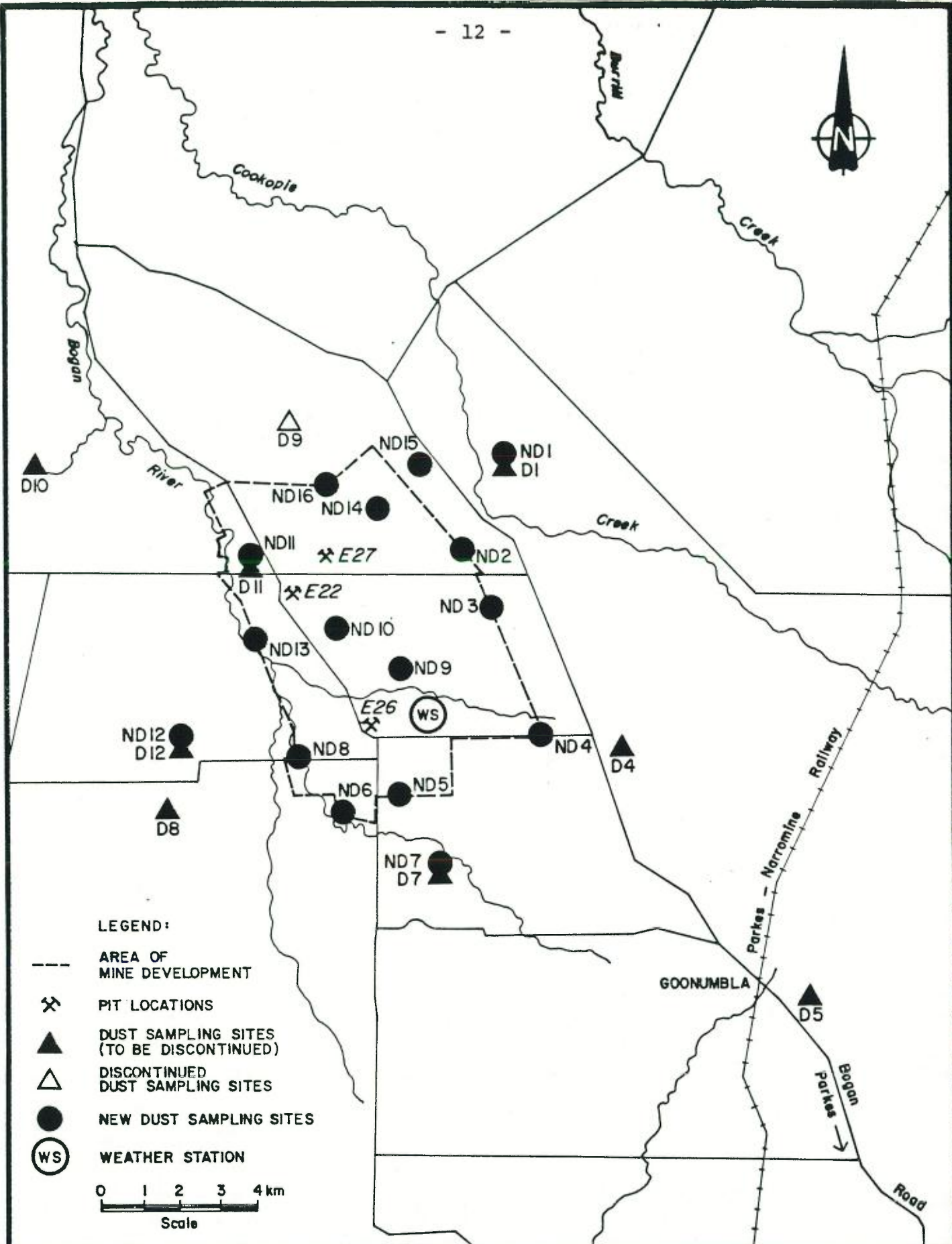
SUMMARY

EXISTING NETWORK

- |    |   |                             |     |   |                      |
|----|---|-----------------------------|-----|---|----------------------|
| D1 | - | Continue as ND1             | D7  | - | Continues as ND7     |
| D2 | - | Discontinue                 | D8  | - | Discontinue          |
| D3 | - | Discontinue                 | D9  | - | Already discontinued |
| D4 | - | Discontinue at present site | D10 | - | Discontinue          |
| D5 | - | Discontinue                 | D11 | - | Continue as ND11     |
| D6 | - | Discontinue                 | D12 | - | Continue as ND12     |

NEW NETWORK

- ND1 - At present D1
- ND2 - On boundary NNE of E26
- ND3 - On boundary NE of E26
- ND4 - On eastern extremity of boundary (relocation of D4)
- ND5 - On boundary SSE of E26
- ND6 - On boundary SSW of E26 (south of centroid of activity)
- ND7 - At present D7
- ND8 - On boundary WSW of E26
- ND9 - 1.5 km NNE by E (34°) of E26
- ND10 - At centroid of mining activity
- ND11 - At present D11
- ND12 - At present D12
- ND13 - On boundary on line between D12 and E22
- ND14 - On extension of line joining E22 and E27, 1.5 km NE of E27
- ND15 - On extension of line joining E22 and E27, 3 km NE of E27
- ND16 - On boundary due north of E27



LEGEND:

- AREA OF MINE DEVELOPMENT
- ⌘ PIT LOCATIONS
- ▲ DUST SAMPLING SITES (TO BE DISCONTINUED)
- △ DISCONTINUED DUST SAMPLING SITES
- NEW DUST SAMPLING SITES
- (WS) WEATHER STATION



Natural Systems Research Pty. Ltd.  
Environmental Consultants

AIR QUALITY SAMPLING SITES  
PARKES REGION

PARKES JOINT VENTURE

GOONUMBLA PROJECT

Compiled by: TB  
Date: DEC 1985

Figure 7

5.0 REFERENCES

Croft & Associates (1985)

Parkes Copper Prospect, Summary of Environmental Monitoring, November 1981 to December 1984; Report to Parkes Joint Venture.

NSR (1983)

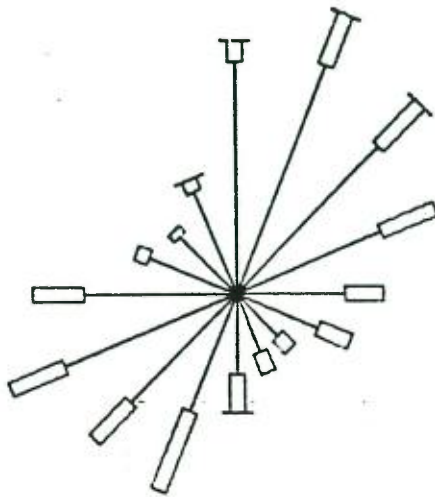
Bayswater Colliery EIS, Meteorology and Air Quality, Report to Maunsell & Partners Pty. Ltd. for Bayswater Colliery Co. Pty. Ltd., CR189.

NSR (1985)

Proposal for Consultant Services for Preliminary Environmental Report, Goonumbla Project Preliminary Feasibility Study, to Peko-Wallsend Ltd., CR 312P.

PEDCO (1978)

Survey of Fugitive Dust from Coal Mines, Report to U.S. Environmental Protection Agency, EPA-908/1-78-003.



SPEED (m/s)    <4   4-10   >10

FREQUENCY (%)    10%

BASED ON HOURLY DATA



Natural Systems Research Pty Ltd  
Environmental Consultants

PARKES JOINT VENTURE

GOONUMBLA PROJECT

WIND TRANSPORT OVERLAY

Drawing No: 312

Date: 19 December 1985

Figure

**APPENDIX K**

**CONTROLLING BLAST-GENERATED  
GROUND VIBRATIONS, AIR VIBRATIONS,  
FLYROCK AND DUST**

Golder Associates Pty. Ltd.

REPORT

TO

NATURAL SYSTEMS RESEARCH PTY. LTD.

ON

CONTROLLING BLAST-GENERATED GROUND VIBRATIONS,  
AIR VIBRATIONS, FLYROCK AND DUST AT GOONUMBLA

JUNE 1986

86610028

**SUMMARY**

Satisfying reasonable environmental limits for blasting at Goonumbia would not be unduly difficult. Provided that Peko were to purchase Altona, Braeside, Estcourt and Pine Grove (these being nearby residences), blasts would produce ground vibrations lower than 5 mm/s and airblast overpressures less than 115 dB at the closest neighbour's dwelling. These vibration limits would have a zero damage potential and would cause minimal disturbance to neighbours. Flyrock would not be hazard. Blast-generated dust would be minimal and momentary.

### CONCLUSIONS AND RECOMMENDATIONS

1. Blasts at Goonumbia would be controlled to the extent that neighbours would not be endangered or unduly alarmed and property would not be damaged.
2. The instantaneous resultant of peak particle velocity of ground vibration (V) would certainly not exceed 5 mm/s at the nearest residence (cf. the Standards Association of Australia's recommended limit of 10 mm/s - see Table 2 and Appendix A).
3. In the absence of site-specific data, values of V should be calculated from the equation:

$$V = 1143 \left\{ \frac{\sqrt{W}}{D} \right\}^{1.6}$$

(W = maximum charge weight per delay in kg and D = blast-residence distance in metres).

4. At the nearest residence (Beechmore), the largest proposed blast would produce a calculated V value of 1.9 mm/s or less.
5. To achieve such low ground vibration intensities, the mine would detonate not more than three charges simultaneously (see Figs. 1, and 2).
6. Airblast overpressures at Beechmore would not exceed 115 dBL, this being the limit set by the NSW State Pollution Control Commission.

7. In the absence of site-specific data, the peak airblast overpressure should be calculated from the imperial (i.e., non-metric) equation:

$$dBL = 162.7 - 19.9 \log \left\{ \frac{D}{\sqrt[3]{W}} \right\}$$

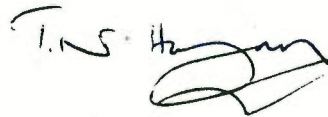
(D in ft., W in lbs.).

8. Under average meteorological conditions, Beechmore would experience an estimated (by calculation) airblast overpressure of 110 dBL. Unfavourable weather conditions could increase this overpressure by 75% (to a value of 114.9 dBL) without exceeding the 115 dBL limit.
9. To achieve such low airblast overpressures, the mine
- (a) would use the stemming lengths and burden distances (see Fig. 3) shown in Tables <sup>2</sup>3 and <sup>3</sup>4,
  - (b) would detonate charges in the sequences and with the delay timings shown in Figs. 1 and 2, and
  - (c) would ensure that these designs are implemented with care and accuracy.
10. Flyrock would be limited to about 100m (cf. the greatest recorded flyrock range of about 750m and the 1600m distance to the closest residence).
11. Flyrock and airblast overpressures would be controlled in the same manner (see Conclusion 9).
12. Blast-generated dust would be minimised
- (a) by using stemming columns with the lengths shown in Tables <sup>2</sup>3 and <sup>2</sup>4, and

- (b) by initiating charges via downlines of 5 g/m rather than 10 g/m detonating cord.
- 13. Blasts would be fired as infrequently as possible.
- 14. Efforts would be made to fire blasts between 9 am and 4 pm Monday through Friday.
- 15. Mine personnel would assure neighbours that blasts
  - (a) will receive considerable amounts of design and implementation effort, and
  - (b) will not cause damage to property.
- 16. Before blasting operations commence, the blast crew would attend a comprehensive on-site seminar dealing with the environmental aspects of blasting.

GOLDER ASSOCIATES PTY. LTD.

per:



Dr. T.N. Hagan

Principal, Blasting Engineer

TABLE OF CONTENTS

1. INTRODUCTION
2. THE UNDESIRABLE SIDE EFFECTS OF BLASTING
  - 2.1 Ground Vibrations
  - 2.2 Air Vibrations (Noise and Airblast)
  - 2.3 Flyrock
  - 2.4 Dust
3. VIBRATION LIMITS
  - 3.1 Ground Vibration Limits
  - 3.2 Air Vibration Limit
4. PREDICTING VIBRATION INTENSITIES
  - 4.1 Predicting Ground Vibrations
  - 4.2 Predicting Air Vibrations
5. CONTROLLING GROUND VIBRATIONS
6. CONTROLLING NOISE AND AIRBLAST
7. CONTROLLING FLYROCK
8. CONTROLLING BLAST-GENERATED DUST
9. RECOMMENDED TIME AND FREQUENCY OF BLASTING
10. PSYCHOLOGICAL ASPECTS OF BLASTING NUISANCES

June 26, 1986

vi.

86610028

APPENDIX A - Blasting in the vicinity of buildings and structures.

DRAFT

LIST OF TABLES

- Table 1** Effects of airblast overpressures on residential structures.
- Table 2** Maximum peak particle velocities of ground vibration recommended by the Standards Association of Australia.
- Table 3** Recommended parameters for ANFO blasts in waste.
- Table 4** Recommended parameters for ANFO blasts in ore.
- Table 5** Predicted maximum peak particle velocities (of ground vibration) at various distances from the largest anticipated blasts (using equation 1).
- Table 6** Predicted airblast overpressures at various distances from the largest anticipated blasts (using equation 3).

LIST OF FIGURES

- Figure 1** Five-row staggered blast shooting to a free face; maximum of three blastholes per delay.
- Figure 2** Five-row staggered blast shooting to a free end; maximum of two blastholes per delay.
- Figure 3** Bench blasting configuration.
- Figure 4** Predicted airblast overpressure relationship for Goonumbla (within USBM's unconfined and RPP bounds).

## 1. INTRODUCTION

In 1985, the writer recommended designs and procedures for drilling and blasting operations at the proposed Goonumbla Mine. The results of that study were presented in Golder Associates' report no. 85630035 dated Nov. 11, 1985. In that report, the environmental aspects of blasting received little attention.

In **this** report, the undesirable side effects of blasting at the proposed mine are considered in detail. More specifically, this report explains the probable effects that blast-generated ground vibrations, air vibrations, flyrock and dust would have on neighbours, structures and facilities in the vicinity of the mine.

## 2. THE UNDESIRABLE SIDE EFFECTS OF BLASTING

The undesirable side effects of surface blasting operations are

- (a) ground vibrations,
- (b) air vibrations (i.e., noise and airblast),
- (c) flyrock, and
- (d) dust.

Each of these side effects is highly transient.

Where blast designs and blasting procedures follow currently accepted standards, explosion energy is liberated in a highly controllable manner; it is **not** unleashed. Under such conditions, each of the above side effects can be limited to a level which is entirely compatible with

- (a) human safety and comfort, and
- (b) the continued integrity of nearby structures and facilities.

## 2.1 Ground Vibrations

When confined (in a blasthole) explosive charges detonate, a fraction of the liberated energy is manifested as seismic energy (i.e., as ground vibrations). Ground vibration takes the form of a wave, generally travelling at 2000-5000 m/s and having a duration up to several times the actual blast duration. When the wave passes a point in the ground, a particle at that point is subjected to motion which can be defined in terms of amplitude, velocity or acceleration, and frequency.

The magnitude of ground vibration depends upon

- (a) the weight of explosive detonated on a given delay period (i.e., at a given instant),
- (b) the distance between the blast and the resident/damageable structure, and
- (c) the characteristics of the strata through which the ground vibration wave propagates.

## 2.2 Air Vibrations (Noise and Airblast)

Noise is the audible part and airblast the (remaining) sub-audible portion of the air vibration spectrum.

Air vibrations are produced from that part of the explosion energy which is vented into the atmosphere and also by the impulsive forward and upward movement of the broken burden rock. This disturbance travels outwards from the blast site as an overpressure front at a velocity of about 345 m/s. Both noise and airblast decay with increasing distance. Because higher frequencies attenuate more rapidly, it is possible, at appreciable distances from a blast, to experience significant airblast (and the consequential vibration of buildings) with minimal blast noise.

Blast-generated noise is impulsive and, therefore, tends to startle people, especially at times of low background noise. The noise level created by a blast is a very poor indicator of damage potential. However, all practicable steps should be taken to ensure that blast noise does not cause undue human response.

Where blast design or blasting practice is poor, airblast can shake buildings, thereby disturbing the occupant(s). At levels considerably higher than those created by good blasts, window panes can be cracked (see Table 1). Airblast can be reduced to very acceptable levels

- (a) by developing efficient blast designs, and
- (b) by implementing these designs with care and accuracy.

### 2.3 Flyrock

Where energetic explosion gases are allowed to escape into the atmosphere, they are at high pressures and, therefore, have the ability to propel flyrock in front of them. Flyrock has been known to travel horizontal distances as great as 750m.

It is important to recognise that a certain amount of lateral displacement of blasted rock is a prerequisite of good blasting results and particularly muckpile looseness. For the proposed blasting operations at Goonumbla, only displacement exceeding about 60m would be classified as flyrock.

### 2.4 Dust

When a blast is fired, some dust is created. This dust results from

- (a) partial or complete ejection of the stemming column,
- (b) the escape of explosion gases through discontinuities and cracks in the face, and

- (c) impacts between rock fragments and between rock fragments and the floor of the bench.

The dust created can be reduced to very small amounts. For a well-controlled blast, the resulting dust usually remains in suspension in the atmosphere at a given location for only a few seconds.

### 3. VIBRATION LIMITS

#### 3.1 Ground Vibration Limits

Of the commonly used construction materials, plaster has the least resistance to ground vibrations. For this reason, most damage criteria are based upon the behaviour of structures which contain plaster.

Current opinion is that the peak particle velocity of ground motion represents the most reliable basis upon which to consider structural damage. Table 2 shows the maximum peak particle velocities recommended by the Standards Association of Australia (see Appendix A).

Ground vibration levels that are completely safe (i.e., that cannot cause damage) can be annoying and even uncomfortable when assessed subjectively by neighbours. So as to keep adverse human response to a practicable minimum, it is recommended that peak particle velocities experienced by neighbouring residences do not exceed 5 mm/s.

#### 3.2 Air Vibration Limit

There is no Standards Association of Australia Code which adequately covers impulsive noise. The NSW State Pollution Control Commission (SPCC) require

airblast overpressures not to exceed 115 dBL. Where this 115 dBL limit is observed, damage does not occur and adverse human response is minimised.

Of the commonly used construction materials, glass window panes have the least resistance to airblast, especially where windows have large areas. It is not surprising, then, that windows are the first to suffer damage as airblast overpressure increases. Large plate-glass windows start to break at about 140 dBL (see Table 1). Because the dBL scale is logarithmic rather than linear, an airblast overpressure of 140 dBL is 17.8 times that of 115 dBL. Where, as this report advocates, the SPCC's limit of 115 dBL is observed, therefore, airblast overpressures do not exceed 5.6% of the overpressure at which large-area windows begin to break.

#### 4. PREDICTING VIBRATION INTENSITIES

In the absence of vibration data recorded at the proposed Goonumbla minesite, one can apply only general empirical equations to predict the vibration intensities at various distances from blasts. As one might expect, the accuracy and value of general predictive equations are usually not as great as those of vibration readings obtained at the proposed minesite. This is particularly the case for ground vibrations (because of the appreciable influence of geological conditions between a blast and the vibration recording site).

Where a general predictive equation is used, it is prudent to employ an equation which has been developed for conditions which are similar to those anticipated at the proposed mine. If such an equation is not available, one should use an equation which applies to conditions that are more severe than those anticipated.

4.1 Predicting Ground Vibrations

Test blasts to develop a site-specific ground vibration equation for Goonumbla have not been fired. Therefore, it is necessary to apply a general predictive equation which has been developed for bench blasting operations.

After spending millions of research dollars over more than a decade, the United States Bureau of Mines (USBM) developed the following ground vibration equation for hard-rock quarries and surface mines:

$$V = 1143 \left\{ \frac{\sqrt{W}}{D} \right\}^{1.6} \dots\dots\dots(1)$$

where V is the instantaneous resultant of the (three) mutually perpendicular components of peak particle velocity of ground motion (measured in mm/s), W is the maximum charge weight per delay period (measured in kg), and D is the blast-structure distance (measured in metres).

It is **important** to note that equation (1) represents **worst-case** situations; it is used as a conservative guide by those who have not established the site-specific vibration constants (i.e., the coefficient of  $\left\{ \frac{\sqrt{W}}{D} \right\}^{1.6}$  and the power to which  $\frac{\sqrt{W}}{D}$  is raised). The writer has used equation (1) to estimate the ground vibrations at various distances from the largest anticipated blasts at Goonumbla.

If, as is recommended, charge weights would be as high as 295 kg (see Tables 3 and 4) and blasts with up to 5 rows would be fired, there would be up to 3 charges detonating on each delay period (i.e., detonating almost simultaneously

- see Figs. 1 and 2). Therefore, W would have a value as high as  
3 x 295 = 885 kg.

Using W = 885 kg in equation (1), one obtains the values of V shown in Table 5.

Using these predicted worst-case ground vibrations, the writer recommends that Peko purchases the following residences:

- Altona
- Braeside
- Estcourt
- Pine Grove

All other residences are so remote from blasting operations that neither they nor their occupants would be adversely affected by ground vibrations.

#### 4.2 Predicting Air Vibrations

The airblast overpressure (dBL) at a given distance (D) from a blast is given by an equation of the form:

$$dBL = k - c \log \left\{ \frac{D}{\sqrt[3]{W}} \right\} \dots\dots\dots(2)$$

where W is the maximum charge weight per delay period.

The values of k and c are influenced appreciably by

- (a) stemming lengths and front-row burden distances (see Fig. 3),
- (b) the degree of progressive relief of burden achieved through the use of inter-row and inter-hole delays, and
- (c) the presence or absence of detonating cord trunklines.

Having monitored airblast overpressures produced by large numbers of blasts in surface mines, the USBM has presented the data shown in Fig. 4. The upper bound of the recorded data represents airblast overpressures produced by unconfined charges (i.e., charges which are detonated in the open air). The lower bound of the recorded data (marked RPP) represents the overpressures created by charges which are excessively confined. Neither of these limiting levels of confinement would apply at Goonumbla; charges would be confined to the extent that explosion gases would be virtually devoid of energy by the time they escape into the atmosphere. Therefore, the relationship predicted for blasts at Goonumbla, viz.

$$dBL = 162.7 - 19.9 \log \left\{ \frac{D}{\sqrt[3]{W}} \right\} \dots\dots\dots(3)$$

is closer to the RPP line than to the line for totally unconfined charges (see Fig. 4). The writer has used equation (3) to predict airblast overpressures for a range of distances from the largest anticipated blasts at Goonumbla (see Table 6).

Using these predicted airblast overpressures, the writer recommends that Peko purchases the following residences:

Altona  
 Braeside  
 Estcourt  
 Pine Grove

All other residences are so remote from blasting operations that neither they nor their occupants are likely to be adversely affected by airblast overpressures. In the event that Beechmore or Rosedale receives a high-velocity wind blowing directly from the blast site, these residences could possible experience an airblast overpressure as high as 115 dBL.

The above finding is compatible with that for ground vibrations, viz. that, from the blast-generated vibrations viewpoint, Peko should purchase only Altona, Braeside, Estcourt and Pine Grove.

#### 5. CONTROLLING GROUND VIBRATIONS

Ground vibrations would be controlled by ensuring

- (a) that the minimum practicable weight of explosive detonates on a given delay number (see Figs. 1 and 2), and
- (b) that most of the explosion energy liberated by the charges on a given delay number is consumed in providing good fragmentation, adequate displacement and a loose highly diggable muckpile rather than in creating ground vibrations.

These aims would be met by observing the following rules.

- (a) Limit the maximum charge weight per delay by using the maximum practicable number of delay periods in each blast.
- (b) Ensure that the burden distance and effective subdrilling are not too large (The values shown in Tables 3 and 4 are recommended.)
- (c) Use the maximum inter-row delay interval which fails to cause cut-offs.

#### 6. CONTROLLING NOISE AND AIRBLAST

Noise and airblast would be controlled by ensuring that all or nearly all of the explosion energy is consumed in fragmenting and displacing the burden rock by the time the gases vent (via the broken burden rock and/or the ejected stemming

material) into the atmosphere. This objective would be met by ensuring

- (a) that all burden distances and stemming lengths are correct, and
- (b) that charges detonate in the correct sequence and with inter-row delays that maximise progressive relief of burden.

Efforts would be made to fire blasts at a time

- (a) when there is a low probability of a temperature inversion, and
- (b) when high-velocity winds are not blowing towards the nearest neighbours.

#### 7. CONTROLLING FLYROCK

Flyrock has been known to travel up to 750m from blasts. But such trajectory distances apply only to uncontrolled blasts.

At Goonumbla, flyrock range would generally be limited to 100m. This degree of control would be achieved by ensuring

- (a) that burden distances and stemming lengths are as shown in Table 3 and 4, and
- (b) that charges do not detonate out of sequence.

#### 8. CONTROLLING BLAST-GENERATED DUST

Blast-generated dust would be minimised most cost-effectively by ensuring that inadequate stemming columns are not ejected for considerable distances into the atmosphere. Stemming columns would be such that their ejection velocities are low.

The recommended use of 5 g/m rather than 10 g/m downlines would result in

- (a) the creation of a smaller-diameter cylindrical void down through each

stemming column and, hence

- (b) less dust emission when the explosion gases jet through and progressively erode the walls of this chimney.

The recommended use of 5 g/m rather than 10 g/m trunklines will result in less dust being thrown up from the dry top surface of the blast block.

#### 9. RECOMMENDED TIME AND FREQUENCY OF BLASTING

Whenever possible, blasts would be fired between 9 am and 4 pm Monday to Friday (inclusive). This period is suitable in that

- (a) the presence of a temperature inversion is less probable at and near midday, and
- (b) neighbours are then more likely to be busy with their daily tasks.

Although it has not been proved conclusively, there are strong indications that neighbours respond more favourably when fewer larger blasts are fired. There are both environmental and productivity incentives to fire blasts of the largest practicable size. Larger blasts do not create higher vibration levels.

#### 10. PSYCHOLOGICAL ASPECTS OF BLASTING NUISANCES

The concerns held by many residents near blasting operations are raised by their fear of the unknown. Neighbours tend to believe that blasts are unpredictable and, therefore, uncontrollable events. Many hold exaggerated views of the ability of blasts to cause damage. Therefore, it would be beneficial to all parties if mine management were to visit the closest neighbours to advise/assure them

- (a) that blasting operations at Goonumbla are scientifically designed and, therefore, highly controlled events,

- (b) that blasts have been designed to eliminate the possibility of damage by ground vibrations, airblast overpressures and flyrock, and
- (c) that the adverse response of neighbours to unexpected impulsive noise has been fully considered in the design and firing of blasts.

DRAFT

TABLE 1

EFFECTS OF AIRBLAST OVERPRESSURES ON RESIDENTIAL STRUCTURES

Peak overpressure			Effect of peak overpressure
dBL	kPa		
180	20.0	(10000%)	Conventional structures severely damaged
>170	>6.3	(>3150%)	Cracking of plaster can develop
170	6.3	(3150%)	Most windows break
150	0.63	(315%)	Some windows break
140	0.20	(100%)	Some large plate-glass windows may break
136	0.127	(63.5%)	USBM interim limit of allowable airblast
135	0.112	(56.0%)	
120	0.020	(10.0%)	Complaints likely
116	0.0127	(6.35%)	} 5 - 6% of peak overpressure at which some large plate-glass windows may break
115	0.0112	(5.6%)	

TABLE 2

MAXIMUM PEAK PARTICLE VELOCITIES OF GROUND  
VIBRATION RECOMMENDED BY THE STANDARDS ASSOCIATION  
OF AUSTRALIA

Type of building or structure	Peak particle velocity (mm/s)
1. Historical buildings and monuments, and buildings of special value or significance.	2
2. Houses and low-rise residential buildings; commercial buildings not included in item 3 below.	10
3. Commercial and industrial buildings or structures of reinforced concrete or steel construction.	25

TABLE 3

RECOMMENDED PARAMETERS FOR ANFO BLASTS IN WASTE

Bench height (m)	12.5
Blasthole diameter (mm)	250
Blasthole inclination (degrees to the vertical)	0
Drilled blasthole length (m)	14.5
Subdrilling (m)	2.0
Assumed unavoidable fallback of cuttings (m)	0.5
Effective drilled length of blasthole (m)	14.0
Effective subdrilling (m)	1.5
Stemming length (m)	8.0
Charge length (m)	6.0
Charge weight (kg)	235
Drilled burden distance (m)	7.0
Drilled blasthole spacing (m)	8.1
Powder factor (kg/m <sup>3</sup> )	0.33

TABLE 4

RECOMMENDED PARAMETERS FOR ANFO BLASTS IN ORE

Bench height (m)	12.5
Blasthole diameter (mm)	250
Blasthole inclination (degrees to the vertical)	0
Drilled blasthole length (m)	15.0
Subdrilling (m)	2.5
Assumed unavoidable fallback of cuttings (m)	0.5
Effective drilled length of blasthole (m)	14.5
Effective subdrilling (m)	2.0
Stemming length (m)	7.0
Charge length (m)	7.5
Charge weight (kg)	295
Drilled burden distance (m)	6.2
Drilled blasthole spacing (m)	7.3
Powder factor (kg/m <sup>3</sup> )	0.52

TABLE 5

Predicted maximum peak particle velocities (of ground vibration)  
at various distances from the largest anticipated blasts  
(using equation (1))

Blast - structure distance (m)	Instantaneous resultant of peak particle velocity (mm/s)
500	12.5
750	6.5
1000	4.1
1250	2.9
1500	2.2
1750	1.7
2000	1.4
2250	1.1
2500	1.0
2750	0.8
3000	0.7
3500	0.6
4000	0.4
4500	0.4
5000	0.3

TABLE 6

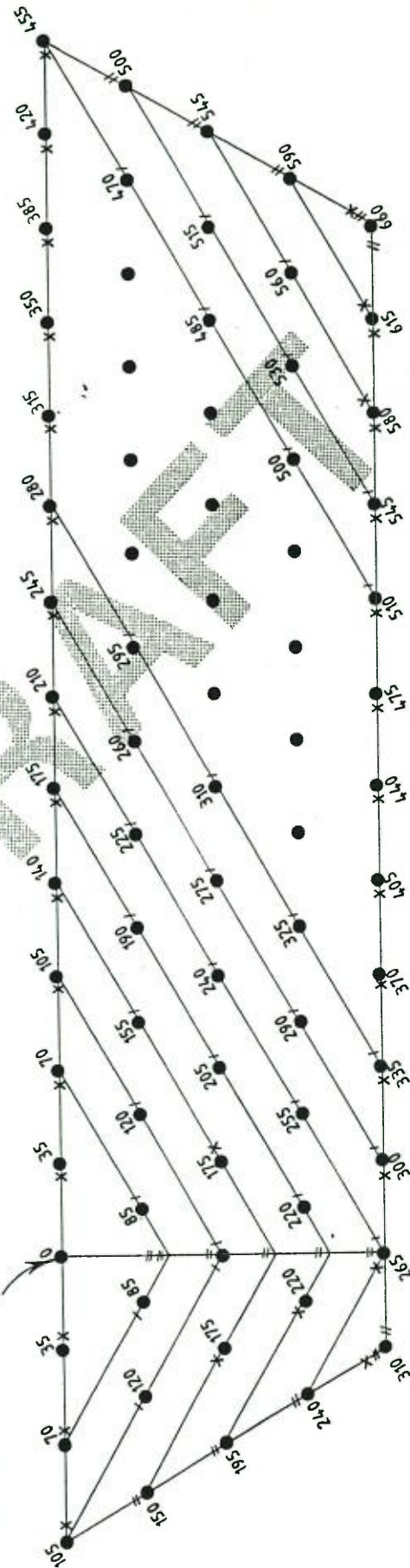
Predicted airblast overpressures at various distances from the largest anticipated blast (using equation (3))

Blast - structure distance (m)	Airblast overpressure (dB)
500	120.6
750	117.0
1000	114.6
1250	112.6
1500	111.1
1750	109.7
2000	108.6
2250	107.6
2500	106.6
2750	105.8
3000	105.1
3500	103.7
4000	102.6
4500	101.6
5000	100.7

FIVE-ROW STAGGERED BLAST SHOOTING  
TO A FREE FACE  
MAXIMUM OF THREE BLASTHOLES PER DELAY

FIGURE 1

FREE FACE



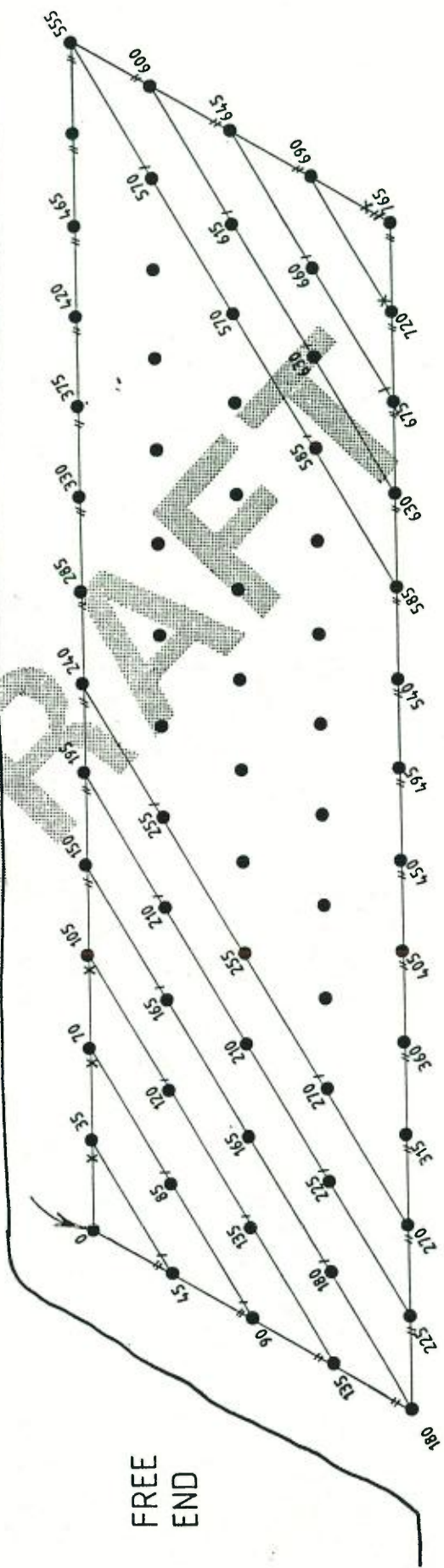
Job No 866/0028

FIVE-ROW STAGGERED BLAST SHOOTING  
TO A FREE END  
MAXIMUM OF TWO BLASTHOLES PER DELAY

DRAFT

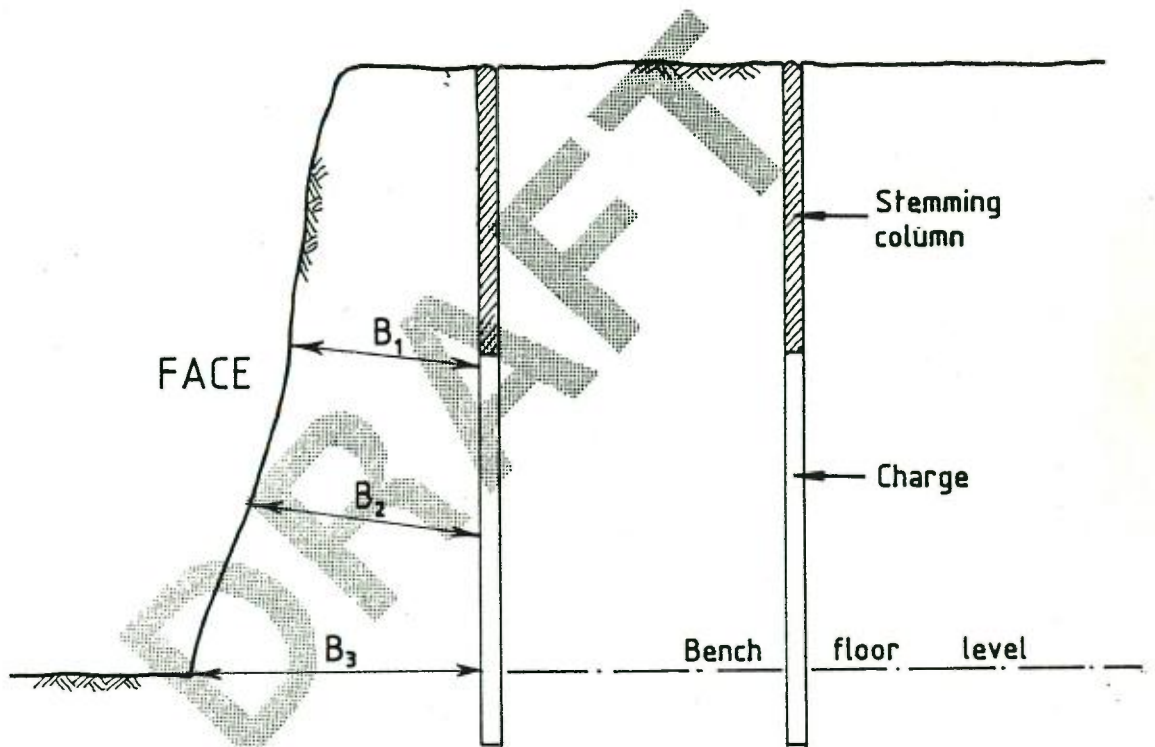
FREE FACE

FREE END



Job No 86610028

rev 01 10/00

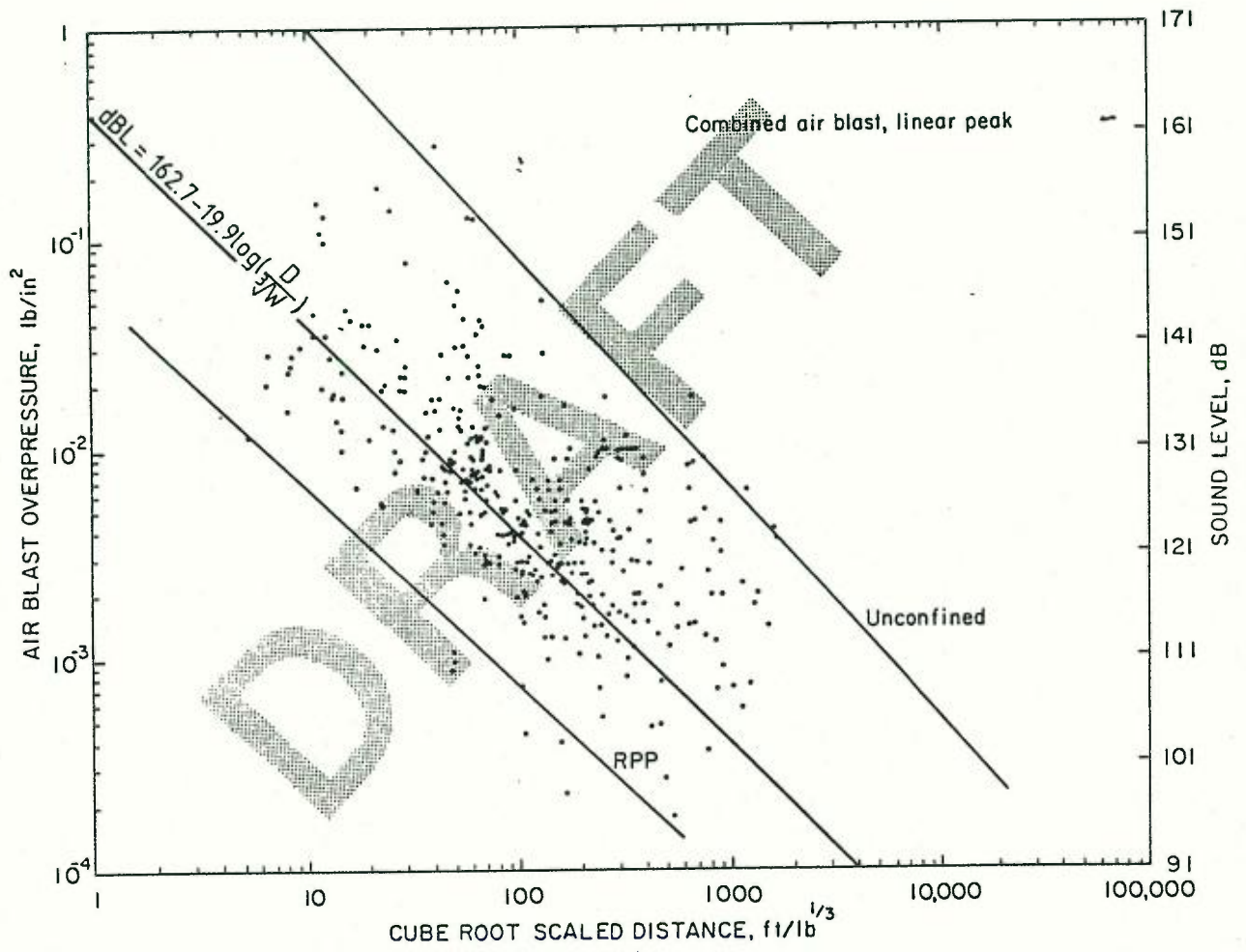


B = Front row burden distances

Job No 866/0028

PREDICTED AIRBLAST OVERPRESSURES  
WITHIN USBM'S UNCONFINED & RPP BOUNDS

FIGURE 4



Job No 86610028

APPENDIX A

RELEVANT SECTION OF SAA EXPLOSIVES CODE

PART 2 - USE OF EXPLOSIVES (1983)

# Australian Standard 2187, Part 2—1983

---

## SAA EXPLOSIVES CODE Part 2—USE OF EXPLOSIVES



STANDARDS ASSOCIATION OF AUSTRALIA  
*Incorporated by Royal Charter*

## SECTION 11. SPECIAL HAZARDS

**11.1 BLASTING IN THE VICINITY OF SOURCES OF ELECTROMAGNETIC RADIATION.** Where electric detonators are used to initiate explosive charges, they shall be used at such distances from sources of electromagnetic radiation that a substantial factor of safety is provided against the possibility of induced ignition of the detonators from such sources.

NOTE: Recommendations for safe distances are contained in BS 4992. An extract from BS 4992 appears as Appendix D.

**11.2 BLASTING IN THE VICINITY OF BUILDINGS AND STRUCTURES.**

**11.2.1 Vibration.** Where blasting is carried out in proximity to buildings or structures, ground vibration shall be kept within limits related to the probability of damage and/or human discomfort.

NOTE: Vibrations transmitted through the ground may cause damage to buildings or structures and/or discomfort to their occupants. The likelihood of such damage or discomfort may be ascertained by measuring, near the building or structure, the ground vibration originating from a blast. Ground vibrations should normally be measured near the building or structure with the instrument placed between the source of the blast and the building or structure.

The choice of locations for the measurement of ground vibration and the actual measurement should be carried out by persons competent in such matters.

It is recommended that ground vibration be measured by ascertaining the peak particle velocity. The peak particle velocity ( $V_p$ ) is the vector sum of three velocity components and, when not directly measured by an instrument, may be determined by the following formula:

$$V_p = \sqrt{V_x^2 + V_y^2 + V_z^2}$$

where  $V_x$ ,  $V_y$  and  $V_z$  are the instantaneous components of particle velocity on x, y and z axes respectively.

The peak particle velocity measured at the ground surface should not exceed the limits recommended in Table 11.2 as amplified by the footnotes thereto.

Factors affecting ground vibration are outlined in Appendix K.

**TABLE 11.2**  
**RECOMMENDED PEAK PARTICLE VELOCITY**

Type of building or structure	Particle velocity ( $V_p$ ) mm/s
1. Historical buildings and monuments, and buildings of special value or significance	2
2. Houses and low-rise residential buildings; commercial buildings not included in item 3 below	10
3. Commercial and industrial buildings or structures of reinforced concrete or steel construction	25

## NOTES:

- This table does not cover high-rise buildings, buildings with long-span floors, specialist structures such as reservoirs, dams and hospitals and buildings housing scientific equipment sensitive to vibration. These require special considerations which may necessitate the taking of additional measurements on the structure itself, to detect magnification of ground vibrations which might occur within the structure. Particular attention should be given to the response of suspended floors.
- In a specific instance, where substantiated by careful investigation, a value of peak particle velocity other than that recommended in the table may be used.
- The peak particle velocities in the table have been selected taking no consideration of human discomfort and the effect on sensitive equipment within the building. In particular, the limits recommended for buildings Types 2 and 3 may cause complaints.

**11.2.2 Airblast overpressure.** Where blasting is carried out in proximity to buildings or structures, airblast overpressure shall be kept within limits related to the probability of damage and/or human discomfort.

NOTE: Airblast overpressure can cause discomfort to persons and in some cases damage to structures. Acceptable levels for airblast overpressure may be obtained from the appropriate authority. The effect of airblast overpressure on structures should not be confused with the effect of ground vibration. Major factors affecting airblast overpressure are the following:

- Magnitude of blast.
- Exposure of explosives.
- Topography.
- Atmospheric conditions.

**11.2.3 Precautions.** Where protection from the possibility of fly-rock is necessary, blasting mats or other suitable cover shall be used and the size and number of charges shall be limited.

Unconfined plaster or blister shots shall be permitted only where drilling of the rock to be blasted or other methods of fragmenting the rock are impracticable, and in any case, noise levels shall comply with the requirements of the appropriate Regulatory Authority.

## NOTES:

- In large-scale operations where blasting mats or cover cannot be used, a method employing delay detonation is recommended.
- Blister shots are often the cause of complaint of alleged damage by air blast.
- Some attention should be paid to the assessment of noise levels in residential areas.

**11.3 ATMOSPHERIC ELECTRICAL ACTIVITY.** If there is evidence of any form of atmospheric electrical activity or disturbance, blasting operations shall be suspended and such operations shall not be resumed until the electrical disturbance has dissipated.

## NOTES:

- An additional degree of hazard may be present in underground working, e.g. conduction of electrical energy by water-bearing zones or metal locomotive rails, or conditions favouring the generation of static electricity.
- Specially designed instruments to detect lightning are available and their use should be considered.

**11.4 BLASTING UNDER WATER.**

**11.4.1 Precautions.** For blasting under water, no blast shall be fired when any person is in the water in the vicinity of the operations. Additional care shall be taken in waters such as estuaries or near beaches as the pressure pulse effects are more pronounced in water up to 10 m deep.

Concussive effects shall be estimated for unconfined charges from the following formula:

$$P = 54.6 \times 10^3 \left( \frac{m^{1.3}}{R} \right)^{1.13}$$

where

$P$  = peak pressure, in kilopascals

$m$  = mass of explosives, in kilograms

$R$  = distance from charge to point affected by pressure, in metres

Rough estimates may be made using the approximation —

$$P = 55 \times 10^3 \frac{m^{1.3}}{R}$$

## **APPENDIX L**

### **EXAMPLES OF DUST GAUGE SITING & SERVICING RECORDS**

- Example of Location Record
- Example of Location Plan
- Example of Monthly Dust Gauge  
Service Proforma

Source: Jones (1986). Parkes Joint Venture: Goonumbla Project Dust  
Gauge Siting Installation Report. Geopeko, Parkes NSW,  
June 1986.

Gauge: ND12

Co-ordinates:  $2^{06855E}$ ,  $13^{52605N}$  ISG Zone 55/3

Gauge Height: 2.01m

Property: "Fernleigh"

Reason for Site: Existing gauge (D8). Adjacent to "Fernleigh" house.

Sited as Proposed: No

Comments: Originally proposed to duplicate D12 however this gauge was regularly vandalised. D12 was a check gauge for D8.

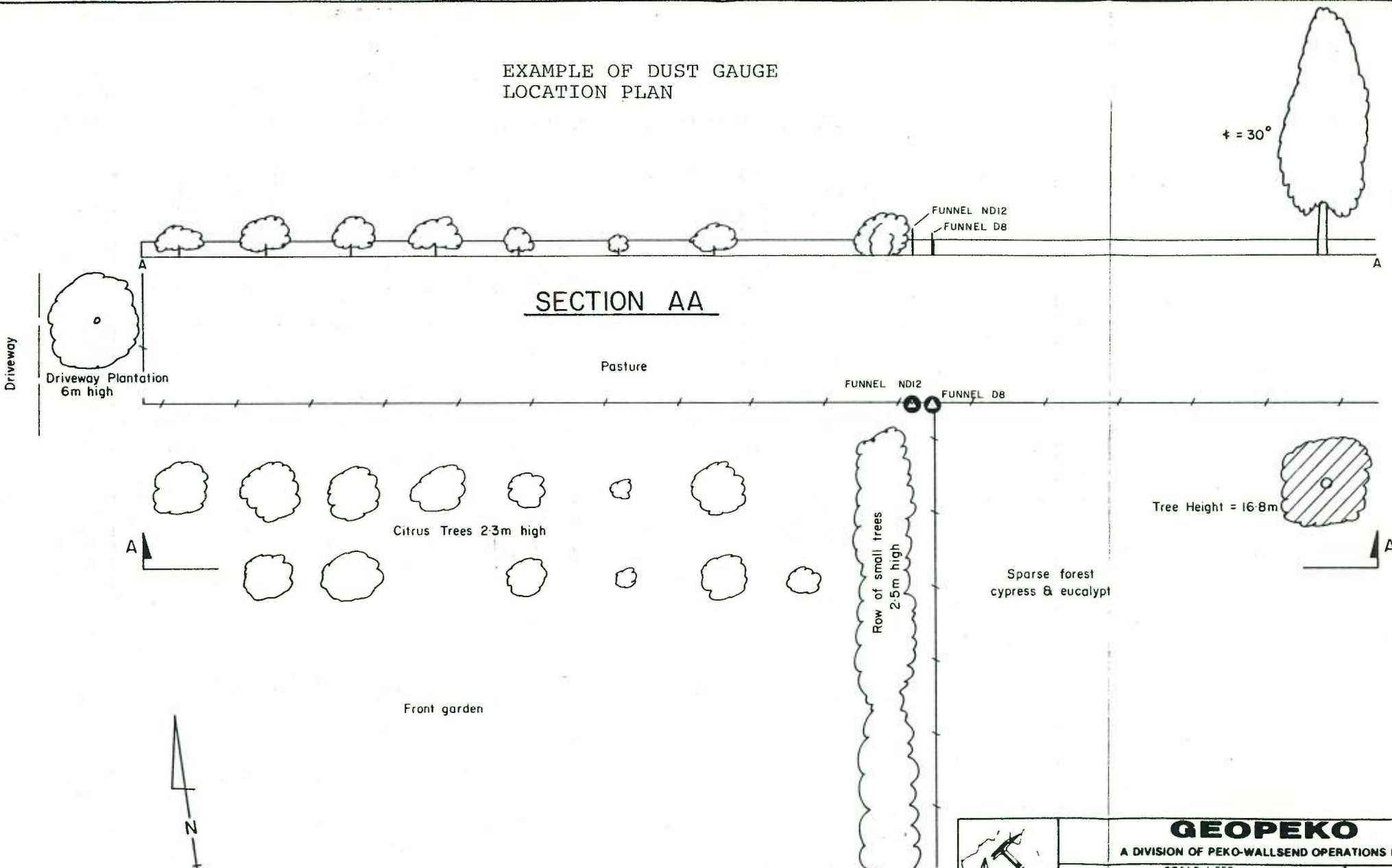
Site Description: See diagram.

Site Compliance with AS2724.1? No

Comments: See diagram.

EXAMPLE OF LOCATION  
RECORD

EXAMPLE OF DUST GAUGE  
LOCATION PLAN

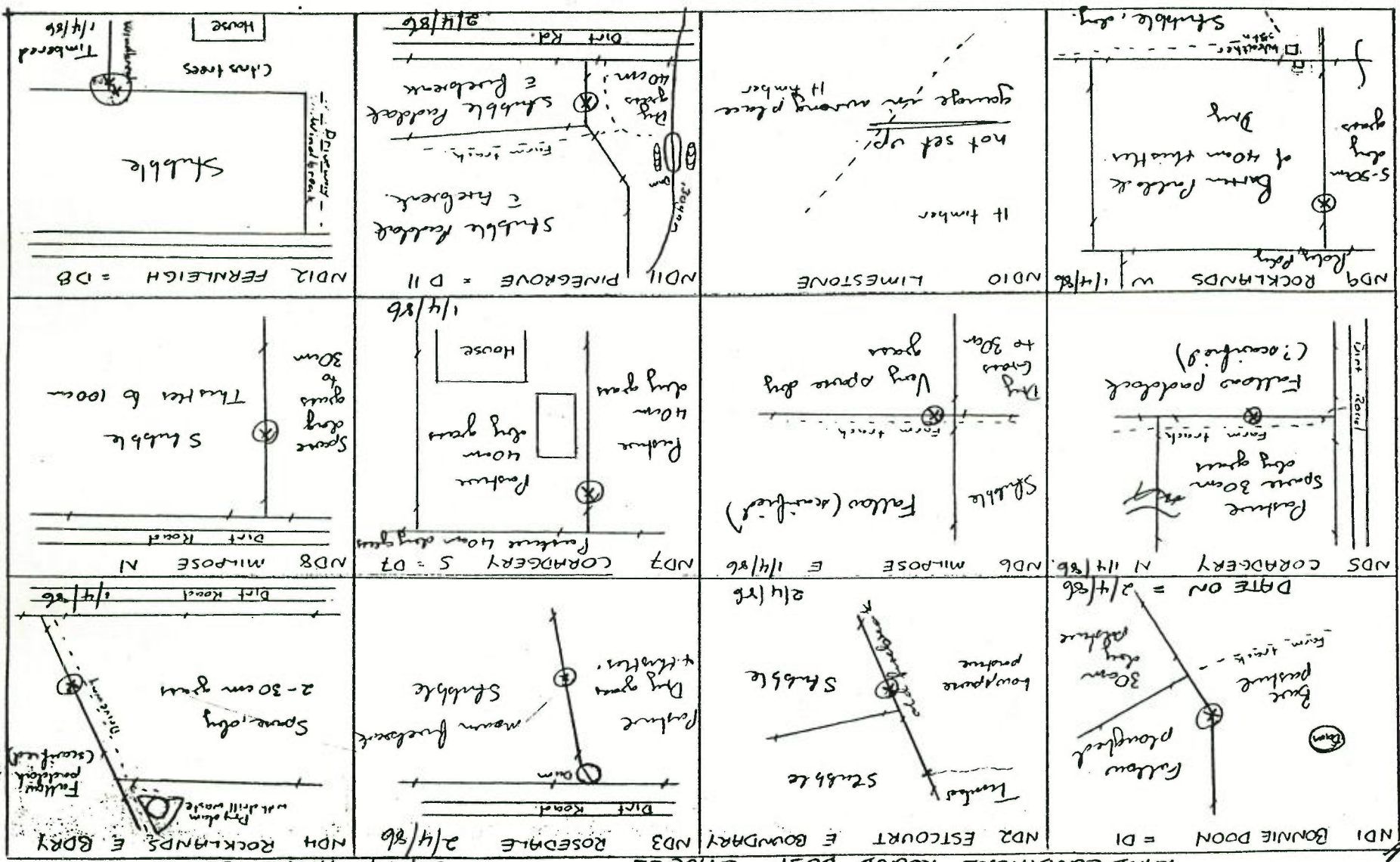


SECTION AA

PLAN

	<b>GEOPEKO</b>	
	A DIVISION OF PEKO-WALLSEND OPERATIONS LTD	
	SCALE 1:250	No. A3-632
Date	18-6-86	
Geologist	RLJ	
Checked		
Drawn	RMN	Map Ref
		Base
		<b>PARKES NSW</b>

EXAMPLE (OF MONTHLY DUST GAUGE SERVICE PROFORMA



LAND CONDITIONS ROUND DUST GAUGES EARLY APRIL '86

Diagrammatic only, Not to scale

**APPENDIX M**

**SOCIAL AND PHYSICAL INFRASTRUCTURE**

Mitchell McCotter & Associates Pty Ltd.

PARKES COPPER-GOLD PROJECT:  
SOCIAL AND PHYSICAL INFRASTRUCTURE  
REPORT

Prepared for:  
PEKO-WALLSEND LTD

Report No. 88032/6  
January, 1989

## TABLE OF CONTENTS

	Page No.
1.0 INTRODUCTION	1
2.0 EXISTING SOCIO-ECONOMIC ENVIRONMENT	2
2.1 AREA UNDER STUDY	2
2.2 POPULATION CHARACTERISTICS	3
2.2.1 Population Change	3
2.2.2 Demographic Characteristics	3
2.2.3 Employment Characteristics	4
2.3 HOUSING AND COMMUNITY FACILITIES	6
2.3.1 Supply of Housing and Residential Land	6
2.3.2 Community Facilities	8
2.4 UTILITIES AND URBAN INFRASTRUCTURE	9
2.4.1 Roads and Traffic	9
2.4.2 Water Supply	12
2.4.3 Sewerage System	14
3.0 PROFILE AND IMPACT OF THE CONSTRUCTION WORKFORCE	15
3.1 CONSTRUCTION WORKFORCE CHARACTERISTICS	15
3.1.1 Profile and Size	15
3.1.2 Sources of Construction Workforce	15
3.1.3 Associated Population	16
3.1.4 Residential Locations of Construction Workforce	16
3.2 SOCIAL IMPACT OF CONSTRUCTION PHASE	17
4.0 PROFILE AND IMPACT OF THE OPERATIONAL WORKFORCE	20
4.1 OPERATIONAL WORKFORCE CHARACTERISTICS	20
4.1.1 Profile and Size	20
4.1.2 Sources of Operational Labour	30
4.1.3 Residential Location of Workforce	27
4.1.4 Associated Population	29
4.1.5 Impacts on Community Facilities	30
4.1.6 Impacts on Housing and Urban Land	33

TABLE OF CONTENTS (Continued)

	Page No.
5.0 IMPACTS ON UTILITIES AND URBAN INFRASTRUCTURE	35
5.1 ROADS AND TRAFFIC	35
5.1.1 Transport of Product and Equipment	35
5.1.2 Workforce Commuting	35
5.1.3 Impact Upon Local Road Capacity	37
5.1.4 Impact on Road Maintenance	40
5.2 WATER SUPPLY AND SEWERAGE	41
5.2.1 Impacts on Town Water Supply	41
5.2.2 Impacts on Sewerage	42

REFERENCES

ABBREVIATIONS USED IN THIS REPORT

ABS	Australian Bureau of Statistics
CBCS	Commonwealth Bureau of Census and Statistics
CCPA	NSW Combined Colliery Proprietors Association
CES	Commonwealth Employment Service
DMR	NSW Department of Main Roads
EP	Equivalent Population
GP	General Medical Practitioner
km	kilometre
LEP	Local Environmental Plan
LGA	Local Government Area
Ltd	Limited
m	metre
ML	megalitre
mm	millimetre
NSW	New South Wales
pers. comm.	personal communication
PWD	NSW Public Works Department
SD	Statistical Division
SLA	Statistical Local Area
St.	Saint

## 1.0 INTRODUCTION

This report addresses the social and workforce infrastructure implications of the Parkes Copper-Gold Project, and provides the basis for these aspects to be reported by the EIS for the project.

The study predicts the extent to which the project's manpower requirements can be met by the existing workforce of Parkes Shire, and the extent to which additional workers will need to be recruited from outside the Parkes area. The expected demographic characteristics of the project workforce population and multiplier are analysed, from which the demands for housing and services can be inferred. The existing facilities and resources in Parkes are described and analysed in terms of their ability to service the new population.

In general, a pattern of declining population over the past decade has left spare capacity in a number of services and resources, but there are areas where existing supply is projected to fall short of projected demand and these are noted.

Overall, the project represents a large capital investment in the Parkes area against a background of a contracting regional economy and the economic and social benefits flowing from this investment will be correspondingly significant.

A preliminary copy of this report was provided to Parkes Shire Council for comment and issues were identified which required more detailed consideration. A supplementary report is currently in preparation and this will specifically address the issues raised by Council, notably the provision of certain community facilities.

2.0 EXISTING SOCIO-ECONOMIC ENVIRONMENT

2.1 AREA UNDER STUDY

For the purposes of social impact assessment the area of relevance is the project's labour catchment area.

It is anticipated that the primary area of domicile of the operational labour force will approximate the Parkes Shire. This area includes all population centres within 40 kilometres of the site, and previous studies of mine workforces in rural areas of the Hunter Valley have shown that the normally acceptable commuting distance is in the order of 40 kilometres (Croft & Associates Pty Ltd, April 1982, p.85). Another more detailed investigation into the places of residence of the labour force at two Hunter Valley mines indicated that 83% of the labour force lived in towns or villages within approximately 40 kilometres of the site, a further 12% in towns or villages outside this radius, and a further 5% on rural residential or farm allotments generally within 40 kilometres of the mines (Mitchell McCotter, in prep).

In the Parkes locality there are a number of towns outside this primary labour catchment area which may contribute a proportion of the workforce. These towns are listed in Table 2.1.

TABLE 2.1  
TOWNS ON OUTSKIRTS OF LABOUR CATCHMENT

Town	Approximate Distance From Site
Forbes	60 kilometres
Dubbo	95 kilometres
Narromine	85 kilometres

On the basis of this information it is estimated that during the working life of the project, 90% of the labour force will reside in the Shire of

Parkes, and 10% in areas outside the LGA (mostly Forbes). Consequently, the investigation of sources of labour and socio-economic impacts associated with the project will focus on the Shire of Parkes.

## 2.2 POPULATION CHARACTERISTICS

### 2.2.1 Population Change

The population of the Shire of Parkes has declined by 2.4% over the period 1976 to 1986. While this may appear marginal, it contrasts significantly with State trends, as the population of NSW increased by over 13% in the same period. Figures on internal migration show that between 1976 and 1981, 2706 persons moved into Parkes while 3403 moved out (ABS, 1982). It is expected that a pattern of net out migration continued between 1981 and 1986 and is to some extent responsible for the population decline during that intercensal period.

Table 2.2 provides population figures for the Shire (SLA), Central West and NSW.

TABLE 2.2  
POPULATION

Area	1976	1981	1986	76-86 % change
Parkes SLA	14408	14431	14057	-2.4
Central West SD	155461	159684	161197	+3.7
NSW	4777102	5126217	5401881	+13.1

Source: ABS and CBCS

### 2.2.2 Demographic Characteristics

An age profile of the study area's population is presented in Table 2.3. It indicates that the population of Parkes Shire is comparatively older than that for NSW. This is consistent with the out-migration discussed

in Section 2.2.1, as people of working age generally tend to move towards larger urban centres.

TABLE 2.3  
AGE PROFILE

Age (Years)	Proportion of Population (%)	
	Parkes SLA	NSW
0-4	8.3	7.6
5-19	24.3	23.4
20-49	27.6	43.6
50-64	22.0	14.3
65 +	17.7	11.0

Source: ABS 1986

### 2.2.3 Employment Characteristics

Data from the 1986 census has been used to examine the characteristics of the existing labour force in the Shire of Parkes. Unemployment and the characteristics of the unemployed are discussed further in Section 4.1.1.

Table 2.4 indicates that 22% of the labour force are engaged in the agricultural industries. There is very little secondary industry in the area with only 4% of the labour force working in manufacturing, while the tertiary sector is characteristically large. The transport sector stands out as being a considerably larger employer than for NSW as a whole, reflecting the importance of Parkes as a central location on the Newell Highway and as a wheat distribution centre. There has been little change in the relative importance of industries between 1981 and 1986.

TABLE 2.4  
INDUSTRY OF EMPLOYMENT

	Proportion of Workforce		
	Parkes SLA		NSW
	1981	1986	1986
Agriculture	22.1	22.2	4.7
Mining	0.9	0.6	1.3
Manufacturing	4.7	4.0	15.4
Utilities	1.8	1.2	2.1
Construction	5.5	5.2	6.7
Wholesale/Retail	16.0	16.4	18.9
Transport	8.8	10.8	5.7
Communication	3.6	3.2	2.2
Business Services	4.9	5.4	11.7
Public Administration	3.8	4.5	5.5
Community Services	14.1	17.2	16.4
Recreation, Personal	5.7	6.2	6.3
Not classified	8.1	0.5	0.1
Total (including not stated)	100	100	100

Source: ABS

The occupational status of workers is shown in Table 2.5. This is similar to the occupational distribution for NSW with the notable exception of managers and administration. This is because many farmers and graziers are included in this classification.

TABLE 2.5  
OCCUPATIONAL STATUS

	Proportion of Employed Labour Force	
	Parkes	NSW
Managers and Administrators	24.0	11.2
Professionals	7.8	12.2
Para-professional	5.3	6.2
Tradespersons	13.6	15.0
Clerks	12.1	18.0
Sales & Personal Service	11.4	12.2
Plant and Machine	8.3	8.2
Labourers and related	14.7	14.2
Inadequately described	1.1	1.5
Total (including not stated)	100	100

Source: ABS 1986

### 2.3 HOUSING AND COMMUNITY FACILITIES

#### 2.3.1 Supply of Housing and Residential Land

##### (i) Rental Accommodation

At the present time there is a shortage of rental accommodation in Parkes and elsewhere in the Shire. Consultation with two of the area's main real estate agents has indicated that demand currently exceeds supply by a significant margin and that there is little prospect of this situation being relieved in the foreseeable future, as only a small number of rental dwellings are currently being developed. Accordingly, it is considered that there will be little, if any, spare capacity in the existing rental market to accommodate any additional demand that

would arise from the project and the implications of this are discussed in Sections 3.1.4 and 4.1.6.

(ii) Supply of Residential Accommodation

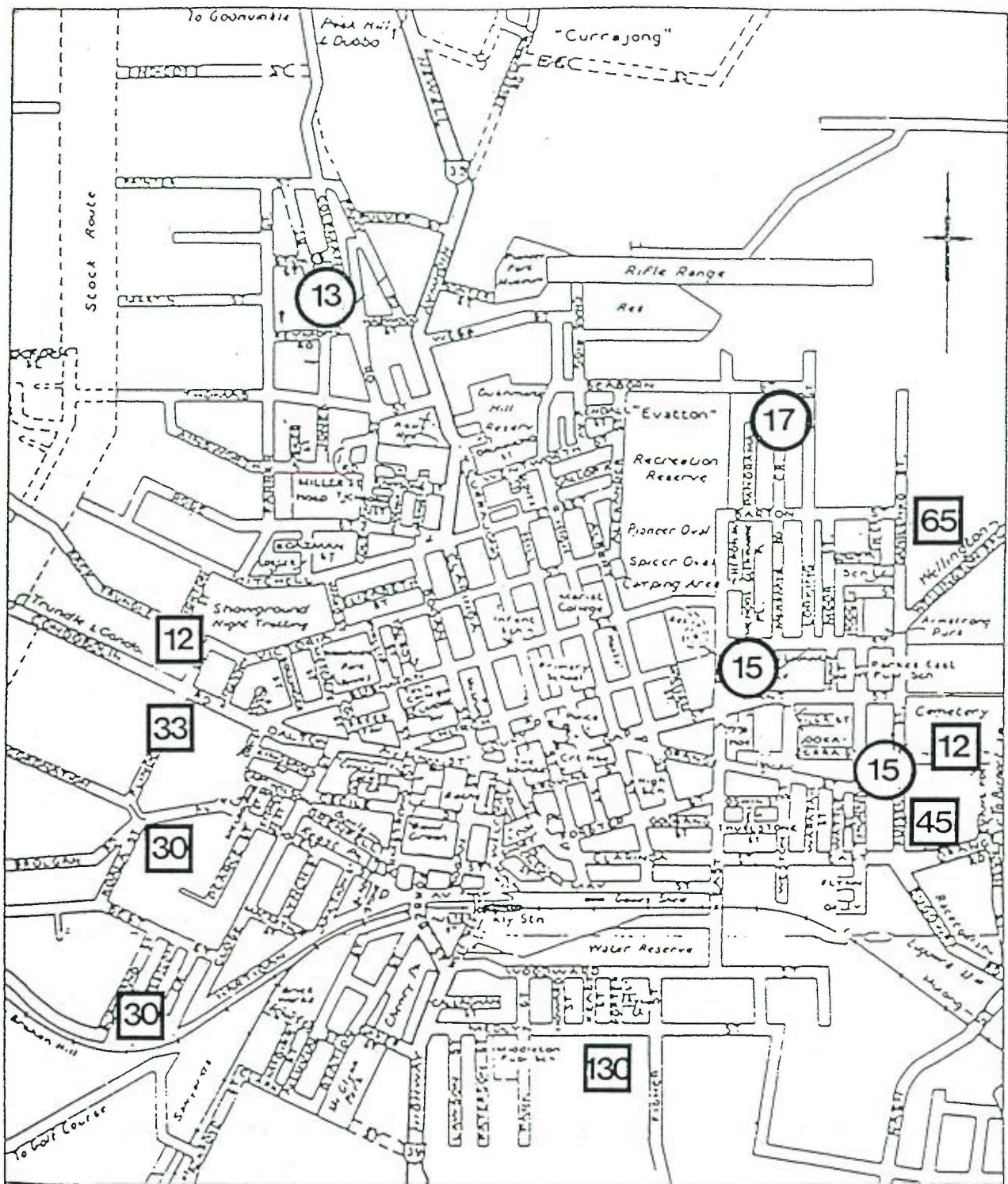
In recent years a tightening in the availability of dwellings for purchase has been reported in Parkes and surrounding townships by local real estate agents. This was considered by the real estate agents surveyed to be the result of supply constraints due to a decline in building activity that has generally occurred in the locality. At the present time it is estimated that there are about 40 to 50 houses, town houses and flats available for purchase in Parkes, about 8 in Peak Hill and about 6 in Trundle.

This level of supply is adequate to accommodate immediate market requirements, being equivalent to about 2.3% of the total owner/purchaser dwelling stock in Parkes. However, the available supply could not accommodate any significant increase in demand, such as that which could be associated with the proposal, as there is an insufficient number of vacant houses to provide adequate choice to prospective purchasers and to control excessive inflation in housing prices. The implications of this for the proposal are discussed in Section 4.2.2.

(iii) Supply of Residential Land

There is a reasonably good supply of serviced residential land currently available in Parkes, that is about 60 lots, located as shown in Figure 2.1. Some reduction in the stock of vacant residential land has occurred in recent years but this has mainly been as a result of alternative forms of development, such as that by the Salvation Army between Flinders Street and Condobolin Road.

In addition to currently serviced blocks, there is a much larger stock of unserviced but appropriately zoned residential land. This is equivalent to about 1350 lots of which 160 lots are in Council's ownership. The implications of this land supply situation for the proposal are discussed in Section 4.2.2.



Vacant serviced residential lots



Unserviced residential lots

Figure 2.1

SUPPLY OF  
RESIDENTIAL LAND

(iv) Supply of Rural Residential Land

At the present time there is not a large supply of rural residential lots in the Shire, as planning controls severely limit the area available. However, Council has recently exhibited an LEP which will greatly increase the number of rural residential lots available in areas around existing towns that can be provided with services at reasonable cost. When this LEP is gazetted there will be a more than sufficient supply of rural residential lots to accommodate any demand associated with the proposal, particularly as there is generally a low level of demand for rural residential land in the Shire.

2.3.2 Community Facilities

(i) Health Facilities

The town of Parkes is served by the full range of health facilities. Parkes District Hospital operates 75 beds including an 11 bed maternity unit. Nine doctors and five dentists practice in the town. In addition, the Parkes Community Health Centre provides services including psychology, drug and alcohol counselling, occupational therapy, speech therapy and early childhood nursing.

(ii) Education

Parkes has three public primary schools and a high school. Two additional primary schools and an infants school are run by religious organisations. According to the Department of Education, enrolments have been declining for several years and all State Schools currently have excess capacity. Technical education is provided at the Parkes Technical College.

(iii) Child Care

Three facilities offer child care in Parkes. The Parkes and District Occasional Child Care Centre provides 20 places. The Parkes Pre-school

can cater for 200 children aged between two and five years, although this is currently at capacity and is fully booked for next year. Family day care is offered through a family day care scheme operated from the Parkes Neighbourhood Centre. This provides the equivalent of 50 full time places, and is currently fully utilised. There is prospect for enlargement of this scheme in the near future.

(iv) Leisure Facilities

A range of entertainment and recreation facilities are available in Parkes. Sporting facilities include bowls, golf, squash, tennis, swimming, as well as facilities for team sports. Cultural facilities include a museum and an art gallery. Recreation facilities are available at licensed clubs in both Parkes and Peak Hill. More extensive facilities are available in the regional centres of Dubbo and Orange.

(v) Welfare Services

Welfare services are provided by an office of the Department of Social Security, the Commonwealth Employment Service, a Community Neighbourhood Centre and the Department of Housing. Private welfare agencies include the St Vincent de Paul Society and other similar groups.

The capacity of all of these facilities to service the population increase that will be associated with the project are discussed in Sections 3.2 and 4.1.5.

## 2.4 UTILITIES AND URBAN INFRASTRUCTURE

### 2.4.1 Roads and Traffic

Access to the mine site from Parkes is possible by two routes:

- (i) north from Parkes along the Newell Highway to the Bogan Road. Thence along the Bogan Road to either the Trundle Road or an

unnamed road for access to either the northern or southern entrances to the mine. Total distance from Parkes to the northern mine entrance is about 31km; and

- (ii) west from Parkes along the Condobolin Road to the Back Trundle Road. Thence along the Back Trundle Road to the southern mine entrance. Total distance from Parkes to the southern entrance is about 34km.

Figure 2.2 illustrates both routes. A short description of each road follows.

#### Newell Highway

On leaving the Parkes urban area the Newell Highway is a two lane sealed road of high standard. Seal width is in excess of 8.0 metres and the seal is in good condition.

#### Bogan Road

This is a sealed two lane road of consistent quality along the 23.5km section to the Trundle Road. Seal width varies from 5.2m to 5.4m with shoulder widths generally 2m or more although occasionally the shoulders narrow to 1m or less, particularly on roadway sections constructed on fill. Seal condition varies from fair to good with occasional undulating or uneven sections and the seal edges are generally broken and uneven.

#### Trundle Road

The section of Trundle Road leading to the northern site entrance is consistent gravel pavement of nominal width 8.5m. There are three gravel causeways on the section leading to the mine.

Condobolin Road

Out of the Parkes urban area the Condobolin Road is a two lane sealed road with a nominal seal width of 8m or less in variable although generally good condition.

Back Trundle Road

This road is variable in condition. For the first 5km from the Condobolin Road the pavement has a single lane seal of nominal width 3.6m with a formation width of about 8m. On leaving the sealed section the gravel formation is variable but generally narrow (less than 6m) and poorly drained. Several sharp 90° bends are also present.

Traffic counts for the local road network are available from the DMR for Condobolin Road and the Newell Highway. Relevant traffic counting stations are shown on Figure 2.2 and data for each station over the 15 year period 1969-1984 is given in Table 2.6. No more recent data is available and Parkes Shire Council have advised they have no data for the local roads being examined.

TABLE 2.6  
TRAFFIC VOLUMES ON THE NEWELL HIGHWAY AND  
CONDOBOLIN ROAD

Station Reference	Traffic Volumes (AADT*)				
	1969	1972	1976	1980	1984
<b>Newell Highway</b>					
- 93002	1360	1490	2120	2650	2890
- 93242	2320	2380	3150	3510	3660
- 93241	4120	5380	5750	6760	7490
- 93122 (Forbes Shire boundary)	1490	1590	2430	2930	2970
<b>Condobolin Road</b>					
- 93243	790	680	880	910	890
- 93688	2490	2230	3600	2590	2360

Source: DMR, 1984

\* AADT, Annual Average Daily Traffic represents the total traffic in both directions

In 1980 the DMR surveyed the traffic composition on the Newell Highway passing station 93002. Over a twelve hour period 2,272 vehicles were recorded of which 1,717 were classified as light vehicles and 555 heavy vehicles. Almost 25 percent of the vehicles were therefore classified as heavy vehicles, a high proportion of the traffic flow. The Newell Highway is the main inland road route between Melbourne and Brisbane and also a section of the inland road network linking South Australia, Victoria and Queensland. The high proportion of heavy vehicle traffic is probably due to the importance of the Melbourne to Brisbane transport linkage and to a lesser extent the other inter-state connections.

#### 2.4.2 Water Supply

Parkes urban area is supplied with water from the Parkes-Peak Hill water supply scheme. Major components of the scheme are:

- . two water sources:
  - (i) Endeavour and Beargamil dams approximately 25km east of Parkes. Water is supplied to Parkes through an old pipeline system with a daily capacity of 4.3ML by gravity and 6.7ML if pump boosted.
  - (ii) the Lachlan River Borefield approximately 30km south of Parkes. There are three bores with a total yield of 13.2ML/day although the pipeline to Parkes has a capacity of 11.9ML/day.
- . a water treatment plant in Parkes of capacity 7.9ML/day. At present only water sourced from the dams is treated, the



93242 DMR Traffic count stations

← N 0 3km

Figure 2.2  
**TRANSPORT AND  
 COMMUTING ROUTES**

treatment involving settlement, filtration, pH correction and fluoridation. Borewater is of satisfactory standard although it is high in iron content. Generally the iron settles out in the system reservoirs however, during periods of peak demand high levels of iron are experienced. Iron is undesirable in public water supplies mainly for aesthetic reasons as it affects the taste of water and may cause staining in laundry and supply fixtures.

- . a reservoir system in Parkes involving 4 reservoirs, 3 of nominal capacity 4.5ML and 1 of nominal capacity 10ML.

The present system is adequate to satisfy current demands. A water supply augmentation strategy study was completed by the Public Works Department in 1984 (PWD, 1984). This report examined augmentation options for the Parkes-Peak Hill water supply scheme to the year 2035. To satisfy demands up to the year 2010 the recommended augmentation works were (PWD 1984):

- a new 375mm diameter pipeline (1988), with the later installation of booster pumps (1986), from Lake Endeavour. A more recent analysis has indicated that work on the pipeline could be delayed until 1990;
- augmented water treatment facilities including treatment of the Lachlan River groundwater (no date given). The work on these is at the feasibility stage and actual construction of these is not programmed for the immediate future; and
- a new 10ML service reservoir in Parkes (already completed).

These works were to satisfy demands up to year 2010 which were estimated as peak daily demands of about 27.4ML and annual demands of 3500ML. No new headworks are required as the existing system has an estimated yield of 3800ML/annum.

After the year 2010 no preferred strategy was determined although three potential schemes were identified which involved further works commencing in the year 2010. These involve either:

- (i) a new 200ML terminal storage in Parkes;
- (ii) duplicate the proposed 375mm main from lake Endeavour; or
- (iii) install 16ML/d pumps on the existing main from the Lachlan bores.

#### 2.4.3 Sewerage System

The entire urban area of Parkes is presently seweraged. Sewage is treated in a treatment plant located approximately 2km to the south east of the town centre. Treatment consists of a trickling filter and maturation ponds and there is generally no discharge from the works. Final effluent is used for irrigation and will also be used to provide a process water supply to the London-Victoria gold mine.

The capacity of the existing plant is 12,000 EP (equivalent population) and the PWD have advised the Shire Council that it is operated at or beyond full capacity. Routine sampling and analysis of the final effluent is performed by the PWD and this has indicated that the plant is at full capacity (pers. comm.).

At present there is no timetable for the augmentation of the existing system. The PWD have previously advised Council that within the site of the present plant there is sufficient space to provide treatment for an additional loading of 8,000 EP.

### 3.0 PROFILE AND IMPACT OF THE CONSTRUCTION WORKFORCE

#### 3.1 CONSTRUCTION WORKFORCE CHARACTERISTICS

##### 3.1.1 Profile and Size

The project will require a construction workforce at four stages; for the initial construction of the mine (1989-1990) and for later periods of expansion. Table 3.1 shows the timing, number and skill requirements of the construction workforce.

TABLE 3.1  
CONSTRUCTION WORKFORCE

Occupational Category	1989	1992	1994	2000	2001
Management/Professionals	12	12	12	23	22
Tradesmen	27	28	27	22	22
Clerical	3	3	3	2	2
Unskilled	16	17	17	18	18
Underground Miners/Operators	-	-	-	65	90
<b>Total</b>	<b>58</b>	<b>60</b>	<b>59</b>	<b>130</b>	<b>154</b>

Previous surveys (NSW CCPA, 1981 and Graham and Collins, 1981) have shown that most construction workers are male, relatively young, almost all under 44 years, and a high proportion, about 50%, are unmarried.

##### 3.1.2 Sources of Construction Workforce

Contractors will be employed to carry out construction work. Therefore, the source of the construction workforce is to some extent dependant on which contractors are retained by the Company for this project.

It is anticipated that some of the construction workforce will be hired from the local labour pool. This is likely to comprise the unskilled workers and perhaps a portion of the clerical staff and tradesmen. For the purposes of this report it is estimated that 33% of the construction workforce (ie. 51 persons at peak in 2001) will be recruited locally. The local pool of unemployed persons is discussed in Section 4.2 and it would appear to be adequate to supply this number of persons. The implication of this is that about 103 workers will be in-migrants to Parkes for the peak construction phase.

### 3.1.3 Associated Population

Construction work is transitory and short term by nature and for this reason only a relatively modest associated population is expected to accompany the in-migrant construction workforce. Little definitive data is available, but general experience in the construction industry indicates that most workers move to the construction site without their families. For instance, a survey of temporary residents in Muswellbrook (Graham and Collins, 1981) showed that only 15% of workers intended to bring their families. On this basis and assuming an average family size of 2.5 persons the total population increase that would occur in the peak construction phase is 125 persons. During the initial construction phase the population increase would be 49 persons.

### 3.1.4 Residential Location of Construction Workforce

The initial construction period will be of approximately nine months duration. During this period the construction workforce and associated population will be accommodated in tourist accommodation in the towns of Parkes and Peak Hill. Accommodation will be required for approximately 33 single males and six families, generating a demand for 23 units, if singles share at two per unit.

This demand will be met through utilisation of existing hotel and motel rooms and on-site caravans. If this proves insufficient additional

caravans will be brought to the area and placed on powered sites in caravan parks.

Table 3.2 provides details of the existing stock of tourist accommodation in the area. It shows that there are 315 accommodation units (hotel/motel rooms and on-site caravans) in Parkes and Peak Hill, and an additional 145 powered caravan sites.

TABLE 3.2  
TOURIST ACCOMMODATION

	Parkes	Peak Hill
Motel units	194	15
Hotel rooms	31	10
Caravan sites (powered)	115	30
On-site caravans	54	11

Source: NRMA, 1988

### 3.2 SOCIAL IMPACT OF CONSTRUCTION PHASE

The construction workforce will be reasonably modest in size, compared to the permanent population of Parkes and will be transient. Whilst there could be some difficulty in integrating a relatively young and predominantly single male population into an established and relatively stable community, adverse social impacts are not likely to be significant. This is because of the relatively small size of the construction workforce and also because the construction phases are of reasonably short duration.

The second potential area of adverse impact is on the availability of short term accommodation. Occupancy rates for tourist accommodation in the Parkes Shire peaks annually in September and October. Table 3.3 provides the available occupancy rates for accommodation in the Parkes LGA.

TABLE 3.3  
PARKES LGA  
ACCOMMODATION OCCUPANCY RATES, 1987

Month	Hotel/Motel with Facilities Room Occupancy Rates (%)	Short Term Caravan Parks Site Occupancy Rates
January	56	22
February	32	15
March	42	14
April	55	19
May	44	17
June	57	19
July	66	22
August	62	24
September	70	27
October	68	25
November	45	18
December	43	20

Source: ABS Tourist Accommodation NSW (8635.1)

This indicates that there is considerable excess capacity in Parkes Shire for much of the year. The demand generated by the initial construction phase is equivalent to 10.5% of the existing stock of accommodation units (excluding caravan sites). It is expected that there should be no difficulty in accommodating construction workers in the available tourist accommodation. However, steps should be taken to ensure that peaks in the number of construction workers do not coincide with peak demand for tourist accommodation in the months of September and October.

It would not be possible to stop major construction activities once they have commenced but the Company will monitor the availability of tourism accommodation during September and October and if a prolonged shortfall

occurs will make arrangements for additional caravans to be brought to the area.

#### 4.0 PROFILE AND IMPACT OF THE OPERATIONAL WORKFORCE

#### 4.1 OPERATIONAL WORKFORCE CHARACTERISTICS

##### 4.1.1 Profile and Size

The project will require a significant workforce growing over a thirteen year period with a peak requirement for 301 people in 2000. A mix of skills will be needed given that the project consists of both open cut and underground mining operations and a processing plant. Details of workforce number, skills and changes over time are given in Table 4.1.

##### 4.1.2 Sources of Operational Labour

The operational labour force for this project will be drawn from three potential sources, namely:

- . those currently unemployed in the area;
- . those currently employed in the area; and
- . in-migration.

A discussion of the available labour force in each category follows.

##### (i) Local Unemployed

##### (a) Number of Unemployed People

There are various counts of the number and rate of unemployed persons in Parkes Shire are available.

Census data indicate that the rate of unemployment in the Shire of Parkes (which is approximated by the Parkes SLA) has increased in the period 1976 to 1986, and has remained higher than both the rates for the Central West Statistical Division and NSW. These data are given in Table 4.2.

TABLE 4.1  
CHARACTERISTICS OF OPERATIONAL WORKFORCE

Occupation	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Senior Management	2	4	5	6	6	6	6	6	6	6
Other Professionals	4	8	8	11	11	16	16	16	16	16
Other Staff	1	15	14	22	30	25	25	25	25	25
Tradesmen	-	11	12	35	45	45	45	45	44	44
Open Cut Operators/ Drivers	20	46	46	84	76	79	74	61	53	53
Underground Operators/ Miners	-	-	-	-	-	-	-	-	-	-
Mill Operators	-	16	22	22	42	42	42	42	42	42
Unskilled-	6	15	12	23	36	36	36	36	36	36
Total	33	115	119	202	246	249	244	231	222	222

TABLE 4.1 (Continued)

Occupation	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Senior Management	7	7	7	6	6	6	6	6	6	6
Other Professionals	21	22	22	22	22	22	22	22	20	20
Other Staff	22	21	21	20	20	20	20	20	20	19
Tradesmen	47	47	47	44	44	44	44	44	42	40
Open Cut Operators/ Drivers	40	33	20	-	-	-	-	-	-	-
Underground Operators/ Miners	68	93	75	75	75	75	75	75	70	65
Mill Operators	42	42	42	42	42	42	42	42	42	42
Unskilled_	36	36	35	33	33	33	33	33	30	28
Total	289	301	269	242	242	242	242	242	230	220

TABLE 4.2  
UNEMPLOYED AS MEASURED BY CENSUS DATA

	1976		1981		1986	
	No.	% of Population	No.	% of Population	No.	% of Population
Parkes SLA	220	2.5	436	3.0	756	7.2
Central West	3,335	2.1	4,524	2.8	7,225	6.0
NSW	111,673	2.3	132,899	2.6	249,138	6.0

Source: ABS

More recent figures from the Australian Bureau of Statistics indicate that in February 1988, 7.7% of the population was unemployed in the North, North West and Central West Statistical Divisions combined. The NSW State Statistical Co-ordination Unit estimates that in June 1987 there were 750 persons unemployed in the Shire of Parkes, indicating little change in local unemployment between 1986 and 1987.

The Commonwealth Employment Service operates an office in Parkes, servicing the local government areas of Parkes, Forbes, Lachlan and Bland. Table 4.3 gives details of the most recent available information on persons registered as unemployed at the Parkes CES office, including estimates of the number of unemployed in Parkes Shire based on the assumption that the number of unemployed people in each LGA is directly proportional to the size of their populations. It is also important to note that the data for the September 1987 quarter is the last showing the total number of unemployed and that for the following two quarters, the table only shows additional people registering as unemployed in the subject period.

TABLE 4.3  
NUMBER OF UNEMPLOYED AS MEASURED BY CES

Date	CES Region	Est. for Parkes LGA
<u>September quarter, 1987</u>		
Unemployed awaiting placement		
Males	1778	617
Total	2514	872
<u>December quarter, 1987</u>		
Persons registering as unemployed		
Males	762	264
Total	1215	421
Placements	391	136
<u>March quarter, 1988</u>		
Persons registering as unemployed		
Males	718	249
Total	1121	389
Placements	249	86

Source: CES

Table 4.4 summarises the recent unemployment statistics available for the Shire of Parkes.

TABLE 4.4  
UNEMPLOYMENT COUNTS - SHIRE OF PARKES

Date	Source	Group	Number
June 1986	Census	Males	475
		Total	756
June 1987	NSW State Statistical Unit	Total	750
September 1987	CES	Males	617
		Total	872

(b) Skills of the Unemployed

The size of the pool of unemployed is of little consequence if the skills available do not coincide with those required for the new project. Table 4.5 gives the occupational categories of the persons unemployed and awaiting placement at the Parkes CES office in September 1987. No more recent data are available.

TABLE 4.5  
SKILLS OF THE UNEMPLOYED  
SEPTEMBER, 1987

Occupation	Parkes CES		Est. for Parkes LGA	
	Males	Total	Males	Total
Management/Administration	5	5	2	2
Professional and related	9	46	3	16
Artistic/Literary	5	6	2	2
Clerical/Sales/Service	153	838	53	290
Primary Production	433	443	150	154
Manufacturing/Construction	233	235	81	81
Transport	148	148	51	51
Basic Manual	792	793	275	275
Other	-	-	-	-
<b>Total</b>	<b>1778</b>	<b>2514</b>	<b>617</b>	<b>872</b>

Source: CES Parkes

For the purposes of this report the skills contained in the occupational categories of primary production, manufacturing/construction, transport and basic manual are considered to be transferable to the mining industry. In addition, the management, professional and clerical categories are likely to make some contribution to the available labour pool, although these types of positions are more likely to be filled by existing Company personnel.

Consequently, it is estimated that in September 1987 there was an unemployed labour pool, with appropriate skills, and resident in the Shire of Parkes of at least 561 people.

It should also be noted that there has been a large number of people in the Shire registering as unemployed since September 1987, that is, 421 people in the December quarter of 1987 and 389 in the March quarter of 1988. For these same periods only 136 and 86 placements were made. Therefore, the total number of persons unemployed in the Shire is likely to be increasing.

(ii) Employed with Appropriate Skills

For people already employed in Parkes Shire, the attractiveness of a change in employment to the Parkes Project will be a personal decision based on a variety of factors. These will include the relatively favourable remuneration conditions normally associated with the mining industry, the location of the site, opportunities for advancement, and the quality of the existing job. It is difficult to estimate the number of jobs at Parkes that will be taken by currently employed people although experience with mining developments in other parts of Australia indicates that this will definitely occur to some degree.

Using 1986 census data on occupation for the Parkes SLA, a potential labour pool of those employed and possessing skills transferrable to the mining sector has been calculated. Table 4.6 gives these selected occupational groups for the area.

TABLE 4.6  
PERSONS EMPLOYED WITH TRANSFERABLE SKILLS

Occupation	Parkes SLA	
	Males	Total
Tradespersons	642	715
Plant and Machine Operators	415	435
Labourers and Related Workers	503	770
Total	1560	1920

Source: ABS, 1986

Not all of the people in these categories have skills that are transferable to the mining industry nor will most of them change occupation, but, nevertheless, they represent a significant potential local labour source.

### (iii) In-migration

The proportion of the project's labour force provided by in-migration will be a function of a number of factors, the most important of which are as follows:

- . the local unemployment rate at the time of recruitment;
- . the skills of the local unemployed;
- . competition for local labour from other development;
- . the Company's recruitment and training policies; and
- . the willingness of local employed persons with appropriate skills to change jobs.

It is anticipated that the unemployment rate in the area will remain stable in the foreseeable future. Only one other major project, the London-Victoria Gold Mine, is expected to provide a boost to local employment opportunities in this period, but only about 50 persons from Parkes Shire are expected to be employed on that project for a period of four to five years.

Company policy will be to recruit locally and provide an appropriate level of basic training. If adequately skilled people are not forthcoming, recruitment will be extended to areas outside the Shire. It is, however, anticipated that people will be brought to the area to fill senior managerial, professional and technical positions.

#### (iv) Origin of Operational Labour Force

A useful guide to the probable labour sources for the project can be gained from the experience at the Ulan Mine which was developed in Mudgee Shire in the mid-1980s. Like Parkes Shire, Mudgee is mainly an agricultural area with little mining or heavy industrial activity. In the period from 1985 to June 1988, the total Ulan Mine workforce increased substantially, from 362 to 860. Despite this large rise the in-migrant component of the labour force remained relatively steady at 21% to 24% of the total labour force (pers. comm. Ulan Coal Mines Ltd). Discussions with representatives of Ulan Coal Mines Ltd have shown that the main occupational category recruited from outside the Mudgee area were underground miners, whereas most positions for tradesmen, truck drivers, labourers and open cut operators were able to be filled locally.

This information is consistent with the experience of mining companies in the Hunter Valley, where a substantial proportion of new mine workers had no previous experience in the mining industry. In September 1985, 64% of those working at Wallsend Borehole Colliery had not previously worked in a mine, while the figure for Stockton Borehole Colliery was 53% and for Mount Thorley 47%.

On the basis of the preceding discussion, the origins of the operational labour force are expected to be as follows:

- . all senior management and professional staff and 50% of other staff will be in-migrants (ie. 40 persons at peak);
- . 50% of underground miners will be in-migrants (ie. 47 at peak);
- . 5% of the remaining labour force, apart from the unskilled, will be in-migrants to accommodate the need for experienced personnel (ie. 6 persons at peak);
- . all unskilled personnel will be obtained locally (ie. 36 persons at peak);
- . 95% of the tradesmen, open cut miners/drivers, and mill operators will be obtained locally (ie. 116 persons at peak);
- . the remaining 50% of other staff will be obtained locally (ie. 10 persons at peak); and
- . the remaining 50% of underground miners will be obtained locally (ie. 46 persons at peak).

Therefore, it is estimated that a total of 208 persons or 69% of the peak labour force will be obtained locally and 93 employees or 31% of the peak labour force will be in-migrants. It should be noted, however, that eight members of the in-migrant workforce are already resident in the area and these are not considered in the following discussions about population growth and community facilities requirements.

#### 4.1.3 Residential Location of Workforce

By drawing on comparable experience with new mining developments in other rural areas (see Section 2.1) it is anticipated that the residential location of the workforce will be:

- . 90% Parkes LGA; and
- . 10% other LGAs, mostly Forbes.

Because of the central location of the project site within the Shire, it is expected that the locally sourced section of the workforce will remain in their current accommodation. Over time, there may be some relocation within the Shire, however, this will generally occur as residential properties and facilities become available.

Of the 85 in-migrating workers, 76 are expected to locate in Parkes Shire and 9 in other LGAs, mainly Forbes as it is not expected that the recently announced upgrading of the abattoirs in that town will cause sufficient population growth to significantly reduce the supply of housing or residential land. The choice of town for new resident in-migrants will be based on a number of factors, including proximity to site, population size of town or village, the availability of suitable accommodation, and the general amenity of the town. Relevant data on selected towns in Parkes Shire is given in Table 4.7.

TABLE 4.7  
CHARACTERISTICS OF TOWNS IN PARKES SHIRE

Town	Population	% of Shire's Population	% of dwellings unoccupied at Census	Distance to Goonumbla (km)
Parkes	8739	62.2	7.6	31
Peak Hill	1097	7.8	9.0	27
Other	4221	30.1	-	-
Parkes LGA	14057	100.0	10.2	-

The information in Table 4.7 shows that Parkes is the most attractive residential location in terms of size, range of facilities and services

available. It is therefore anticipated that 90% of the Shire's in-migrant workforce or 68 people will reside in Parkes, while about 5% (or 4 people) will reside in Peak Hill and the remaining 5% will reside in other towns or rural residential situations.

#### 4.1.4 Associated Population

Information on the characteristics of populations associated with mine workers are available from a study of new arrivals in the Lithgow region (McNair Anderson, August 1980). Relevant characteristics of in-migrants included:

- . 81% married;
- . 65% have children; and
- . 24% of wives lived elsewhere.

The average family size for each married worker was 2.7 people. On the basis of this information, it is estimated that of the project's 85 in-migrant employees 17 will be single, and the remaining 68 will be accompanied by an associated population numbering 116. Therefore, the total population increase as a result of the project is estimated to be 201 persons. Of these 181 (90%) are expected to locate within Parkes Shire and it is this population which is considered further.

The timing of the influx of population into the Shire will coincide with the growth in the project's labour force, particularly when underground miners are being recruited. Major growth periods are in 1989-1993 and 1998-2000, the last coinciding with the introduction of underground mining operations.

Consequently, the population increases associated with the project will be concentrated in the initial phase when the professional and management staff move into the area, and the latter stage when underground miners arrive. Table 4.8 provides estimates of the population increase associated with the mine, and the timing of in-migration.

TABLE 4.8  
POPULATION INCREASES ASSOCIATED WITH PARKES PROJECT \*

Area	Period (years)		Total
	1989-1993	1998-2000	
Parkes Urban Centre	122	41	163
Peak Hill	7	2	9
Other, Town, Village or rural	7	2	9
Parkes LGA	136	45	181

\* Errors due to rounding

#### 4.1.5 Impacts on Community Facilities

The increase in population in the Parkes Shire may require the provision of additional community facilities. The additional demand for these facilities will be dependent on the composition of the incoming population and the timing of the population influx. Table 4.9 provides an indicative breakdown of the composition of in-migrants to the Shire.

TABLE 4.9  
INDICATIVE COMPOSITION OF IN-MIGRANTS TO PARKES SHIRE

	Male	Female	Total
0-4	6	5	11
5-14	11	11	22
15-19	9	5	14
20-44	66	52	118
45-64	8	8	16
65+	-	-	-
Total	100	81	181

It should be noted that the additional population is expected to arrive in the Shire during two periods, 1989-1993 and 1998-2000. The major increase in population numbering over 100 persons, will occur in the initial period and will be spread over three years.

The community facilities considered in Section 2.3.3 are examined in relation to their capacity to accommodate the anticipated population increases in the following sections.

(i) Health Services

Desirable standards for the provision of health services are as follows:

- . GP - 1 per 2000 of population;
- . Dentist - 1 per 3000 of population; and
- . Hospital Beds - 3.5 per 1000 of population.

Based on these standards Parkes Shire currently has an adequate level of health care services and no additional services will be required to cater for the incoming population.

(ii) Education

Discussions with the District Inspector of Schools indicate that all State Schools in the town of Parkes have experienced a steady decline in enrolments over the last decade. It is considered that these schools would have no difficulty in coping with an inflow of school aged children in excess of that associated with the Parkes Project and this was the formal advice of the Department of Education in a submission

following a Planning Focus seminar held for the project in October, 1986.

(iii) Child Care

Existing child care and kindergarten facilities in the town of Parkes are currently fully utilised. However, consultation with child care workers in Parkes has suggested that additional places in residentially based child care schemes are likely to be made available in 1988.

The population associated with the Parkes Project has the potential to generate a maximum demand for about 12 child care places during the developing phase of the project. Because of the timing of the phases of mine expansion and in-migration, there will be little to no overlap in the demand from incoming population groups, as the children arriving in the first phase will grow to school age prior to the next phase occurring. Therefore, it is estimated that a demand for about six places will be generated over the life of the project, although these will service more than one child over that period.

(iv) Welfare

The incoming population will not constitute a burden on welfare services as all will be employed. In fact, the reduction in unemployment levels resulting from job opportunities created by the mine may lessen the workload of public and private welfare agencies.

(v) Summary

In the period since 1976 there has been a 2.4% decline in Parkes Shire's population and a consequent overall lessening in the demand for community facilities and services. At the same time the population has aged, mainly because of out-migration of young people and young families, and this has meant that pressures on particular facilities, such as those for education and active leisure, have declined.

The preceding analysis has shown that most of the Shire's existing facilities have the capacity to accommodate the population increase that will be associated with the Parkes project. This is not unexpected as the population decline that occurred in the Shire between 1981 and 1986 (374 people) is much greater than the population increase expected to be associated with the proposal (210 people) over a fourteen year period. While some pressure may be placed on existing child care facilities, it is important to note that these types of facilities are generally under pressure throughout Australia.

#### 4.1.6 Impacts on Housing and Urban Land

The in-migration of labour will generate additional demand for housing and urban land in Parkes Shire. Table 4.10 shows the in-migrant population by household type and anticipated residential location.

TABLE 4.10  
HOUSEHOLD TYPE OF IN-MIGRANT

Anticipated Residential Location	Singles	Families
Parkes Urban Centre	13	55
Peak Hill	1	3
Other, town, village or rural	1	3
Parkes LGA	15	61

If it is assumed that singles share housing at the rate of 1.5 persons per dwelling and each family occupies a single dwelling, the number of dwellings required and their timing can be estimated, and is shown in Table 4.11. The table also assumes that 75% of singles will live in town houses or flats and the balance of the population will occupy detached houses.

TABLE 4.11  
DEMAND FOR DWELLINGS - PARKES LGA

	1989-1994		1998-1994		Total	
	Town Houses	Detached Houses	Town Houses	Detached Houses	Town Houses	Detached Houses
Parkes Urban Centre	4	43	1	15	5	58
Peak Hill	1	2	-	1	1	3
Other	1	2	-	1	1	3
Total	6	47	1	17	7	64

It has previously been established (see Section 2.3.1) that there is little spare capacity in the area's housing market given the need to control price inflation and to provide adequate choice in the type of dwellings available. Accordingly it will be necessary for the Company to organise the supply of the dwellings given in Table 4.11, over the time period mentioned. This could best be achieved by a Company sponsored housing scheme in which arrangements were made with a bank to provide home purchase finance for the Company's employees who move into the area.

Two further aspects would also require attention. Firstly, the Company will need to ensure that an adequate supply of residential lots is available and this could be achieved either by direct purchase of land or by entering into an agreement with developers to supply the number of lots required. The second aspect is to ensure that adequate capacity is available in the local construction industry to provide the new dwellings required, being mindful of the fact that both mine construction and the associated residential development will occur over the same time period. To ensure that adequate construction capacity exists, the Company will need to make appropriate arrangements with a reputable building contractor to supply houses, probably as a part of the aforementioned financial agreement with a bank.

## 5.0 IMPACTS ON UTILITIES AND URBAN INFRASTRUCTURE

### 5.1 ROADS AND TRAFFIC

#### 5.1.1 Transport of Product and Equipment

It is proposed to develop the mine in two stages. Stage 1 will have an annual concentrate production of 30,000 tonnes and stage two an annual concentrate production of 85,000 tonnes. Concentrate will be transported by rail to Port Kembla for processing or at a later stage may be transported to Newcastle for export. The favoured location for access onto rail is a new siding constructed on the Parkes-Narromine railway to the north of the Goonumbla grain silos as shown on Figure 2.2. It is proposed to transport concentrate from the mine to the siding using trucks carrying enclosed containers with a nett load of 25 tonnes. Assuming 240 effective working days per year then on average 5 container loads will be transported each day during Stage 1 and 15 container loads during Stage 2.

As well as transport of concentrate from the site it will be necessary to deliver mining consumables to the site including fuel, explosives, grinding media and reagents. On average delivery of material to site will require up to 25 heavy vehicle loads per week.

#### 5.1.2 Workforce Commuting

Estimates of workforce requirements indicate a varying construction and operation workforce over the life of the mine. To assess workforce commuting two years have been used, 1991 with a total workforce of 119 which corresponds to peak workforce for the initial 3 years of mining and 2000 with a total operation workforce of 301 and construction workforce of 130 which is the peak workforce up to the year 2008.

As there is no public transport system to the site, workers will need to travel to the site by car. Studies have been carried out in the Hunter Valley assessing the commuting patterns of coal mines that determined the average number of workers per car. Reported car occupancy rates vary from 2.2 workers/car (Mitchell McCotter, 1988) to 2.5-3.0 workers/car (Croft, 1984). For the purposes of this assessment two occupancy rates of 2.2 workers/car and 3.0 workers/car have been used giving a range in generated vehicle numbers. The Hunter Valley surveys were based upon a workforce with a wide range of residence location. The proposed mine workforce will be located within one town and it is likely that a high car occupancy will be achieved. Table 5.1 summarises car movements and likely times of travel for the two years of mining. A two hour band for the times of travel has been indicated which will include the arrival of one shift to work and the departure of the previous shift. All construction workers are assumed to work a day-shift.

TABLE 5.1  
WORKFORCE COMMUTING - CAR MOVEMENTS AND TIMES

	Total Car Numbers			Total Daily
	7.00-9.00am	3.00-5.00pm	10.30-12.30am	Car Movements*
Assuming 2.2 worker/car				
- to 1991	48	52	10	110
- 1992-2008	184	184	24	392
Assuming 3.0 workers/car				
- to 1991	36	38	8	82
- 1992-2008	136	136	20	292

\* 1 return journey equals two car movements

5.1.3 Impact Upon Local Road Capacity

From Parkes access to the site is via a short section of the Newell Highway and thence the Bogan Road. The mine entrance will be located on the Trundle Road approximately one kilometre west of Bogan Road. The alternative route via the Back Trundle Road is not suitable due to its narrow gravel formation. Table 5.2 summarises the total daily vehicle movements generated by the mine. For the delivery of construction materials an average of 5 heavy vehicle movements per day has been assumed.

TABLE 5.2  
PEAK TOTAL DAILY VEHICLE MOVEMENTS  
GENERATED BY MINE ACTIVITIES

		Daily Vehicle Movements			
	Workforce Commuting	Materials Delivery	Concentrate Transport*	Construction Materials	Total
to 1991	82-110	10	10	-	102-130
1992-2008	292-392	10	30	5	337-437

\* Only travels between the mine and Goonumbla siding

The Newell Highway and the intersection with the Bogan Road are of high standard. The increase in traffic along this section of road due to mine traffic will be about 5% of the 1984 AADT up to 1991 and 15% from 1992-2008. This does not consider any growth in the AADT due to other factors. Considering the standard of road these increases will not adversely affect the capacity of the road.

The Bogan Road has a consistent formation between the Newell Highway and the Trundle Road. It has a seal width of about 5.2 to 5.4 metres and generally wide shoulders. No traffic counts are available, however it is a lightly trafficked road probably with an AADT between 100-300.

If Bogan Road is assumed to have an AADT of 300 then mine traffic will increase this to 402-430 up to 1991 and 667-737 over 1992-2008. The National Association of Australian State Road Authorities (NAASRA) have published normal widths of sealed traffic lanes and shoulders on rural roads. These are reproduced in Table 5.3.

TABLE 5.3  
 WIDTHS OF SEALED TRAFFIC LANES AND UNSEALED SHOULDERS  
 FOR UNDIVIDED RURAL ROADS

Design Traffic Volumes (AADT) Vehicles/day	1-150	150-500	500-1000
Normal lane width (m)	One lane - 3.5	two lanes - 3.0	two lanes - 3.0-3.5
Normal shoulder width (m)	1.5-2.5	1.0-1.5	1.0-2.0

Source: NAASRA, 1980

Factors affecting the selection of a design lane width include (NAASRA, 1980):

- . Traffic: higher traffic volumes on a road mean frequent passing and overtaking manoeuvres and the path of vehicles as a result is further from the centre line. In these circumstances, wider traffic lanes are preferred;
- . Vehicle Dimensions: normal steering deviations as well as tracking errors and pavement imperfections reduce the clearance between passing vehicles. Obviously, the wider the vehicles and the narrower the lanes, the more significant these reduced clearances become;

- . Speed Environment: drivers have less control over the lateral position of a vehicle at high speed, therefore, wider traffic lanes, which increase lateral clearances between opposing vehicles, do not require drivers to reduce speed or to increase concentration significantly at the moment of passing; and
  
- . Combinations of Speed and Traffic Volume: when both the speed environment and the traffic volume are high, the narrower lane widths should be avoided. When only one factor is high, an economic design may frequently dictate a narrower lane. This can be justified, on lower volume roads because passing by opposing vehicles occurs less frequently. If the speed environment is high on a low volume road, this would be associated with longer sight distances. Drivers have time to adjust speed slightly or to increase the level of concentration for the passing event. Such events, being relatively infrequent, do not tax the ability of the driver to maintain the higher level of concentration. Even here, however, wider pavements do improve the quality of service of the road.

The horizontal and vertical alignment of Bogan Road are generally good and there are generally long sight distances. The road could therefore be considered to provide a high speed environment.

The characteristics of traffic flows using the mine differ from those normally considered for rural road design. There are definite peak periods when shifts either travel to or from the site. The shifts proposed for the mine have approximately 82% of the operation workforce on day shift. There will therefore be two "slugs" of traffic travelling to or from the mine. Under these conditions one of the main factors influencing lane widths, that of traffic passing in opposite directions, is reduced in importance as all mine traffic will be travelling in one direction, concentrated over a short period of time.

The Bogan Road currently has a lane width of about 2.6-2.7 metres with shoulders generally 2 metres or greater in width although with some

narrower sections. Considering the increase in vehicle movements up to 1991 is 102-130 movements per day with most of this concentrated at the time of day shift arrival or departure the present road is considered adequate except where the shoulder width narrows to less than 1 metre. From 1992-2008 mine vehicle movements increase to a peak of 337-437 movements/day. The present road would not be suited for this volume of traffic due to increased numbers of overtaking movements and the total daily vehicle movements. The following improvements to Bogan Road are recommended:

- . prior to construction commencing. Road shoulders be upgraded to provide a minimum width of 1.5 metres. This is mainly required on sections of roadway constructed on fill; and
- . prior to 1992. Road seal to be extended to a minimum width of 6.0 metres. This could be incorporated with the next resealing of Bogan Road required for normal maintenance purposes.

The Trundle Road has a high standard gravel surfaced formation. As it will carry a significant volume of traffic it is recommended that the section between the mine entrance and Bogan Road be sealed to reduce the maintenance requirements that would be necessary for a gravel formation.

#### 5.1.4 Impact On Road Maintenance

Mine generated traffic would be the main user of Bogan Road in the future. Seasonally during harvest time (November-December) farm vehicles use the Road to transport grain to the Goonumbla sidings. These form a significant proportion of the present usage of the road by heavy vehicles with about 2,500 tonnes of grain delivered during the 1987 harvest.

As the volume of traffic using Bogan Road will increase due to mine traffic by some 43% (up to 1991) up to 146% (1992-2008) the maintenance requirements for the road will need to increase to prevent deterioration in road quality. This includes works such as edge repairs, pothole repairs and the need for surface resealing at shorter intervals.

5.2 WATER SUPPLY AND SEWERAGE

5.2.1 Impacts on Town Water Supply

Expected population increases in the Parkes urban area are derived in Section 4.0 and the demand for dwellings due to in-migrant labour is given in Table 4.11. From these the additional demands upon town water supplies due to mineworkers have been estimated and are summarised in Table 5.4. Although workforce increases will occur over a period of years the earliest year given in Table 4.11 has been used to assess the impacts upon water supply. Demand estimates have been based upon the criteria of 5000L/day/tenement for peak daily demands and 600kL/annum/tenement for annual demands (PWD, 1984). Demand projections used by the PWD were based upon historical data and specifically excluded the possibility of accelerated growth due to mining.

TABLE 5.4  
FUTURE WATER DEMANDS FOR PARKES (ML)

Year	Parkes*		Due to in-migrant Mine Workers	
	Annual	Peak Daily	Annual	Peak Daily
1989	2620	20.3	28.2	0.24
1998	2950	22.9	37.8	0.32

\*Source: PWD, 1984

By the year 1998 the additional demand upon the town water supplies due to the in-migrant workers and families will be approximately 1.3% of the total estimated demand if mining were not to occur or an increase of 11% in the estimated demand increase for the period 1989 to 1998.

The additional demand due to in-migrant workers can be adequately serviced by the present water supply scheme and the augmentation works discussed in Section 2.4.2. These have been estimated to have the

capacity to supply peak daily demands of 27.4ML and annual demand of 3500ML compared to total demands of 23.2ML and 2,988ML estimated for the year 1998. The effect of increased demand due to in-migrant workers may be to bring forward the next stage of augmentation which was not envisaged in the PWD strategy study before the year 2010.

5.2.2 Impacts on Sewerage

The present sewage treatment works is at capacity and needs to be augmented to cater for any future growth in Parkes. No studies have been prepared to estimate the required augmentation works however a preliminary assessment could be made based upon the population projections provided in the PWD water supply augmentation study. The number of occupied tenements to the year 1998 is given in Table 5.5 together with the additional tenements occupied by mineworkers.

TABLE 5.5  
TOTAL OCCUPIED TENEMENTS  
IN PARKES 1988 TO 1998

Year	Forecast Tenement Growth*	Additional Occupied Tenements Due to Mineworkers
1981	(base year) 2989	-
1988	3320	-
1989	3370	47
1998	3850	63

\*Source: PWD, 1984, these figures exclude any allowance for mineworkers

The forecast occupied tenement growth, excluding mineworkers, over the period 1998 is some 530 tenements. If mineworkers are included then the total growth will be about 593 tenements.

Sewage Treatment Plants for country towns are usually designed to be capable of being constructed as a series of modules. As population

increases the plant is augmented in stages. The size of the augmentation modules is variable but is usually in 2000EP or 4000EP stages depending upon the rate of population growth. An occupied tenement can be assumed to have an equivalent loading of 4EP.

Up to the year 1998 the increased amount of sewage requiring treatment will be about 2,120EP based upon the increase in occupied tenements. If in-migrant mineworkers are included this would add a further 252 or roughly 12 percent of the base increase.

Preliminary PWD investigations have indicated that the present site of the sewage treatment plant has sufficient land available to construct works to treat up to 8000EP. Based on the anticipated increase in sewage loadings a new plant designed to be augmented in two 4000EP stages would be reasonable. The first stage to be constructed within the next few years and a second stage in about 15 years.

Two scenarios are considered in assessing the impact of in-migrant mineworkers on the town's sewerage system. If no new treatment works are constructed then the present plant will be overloaded and effluent quality will decline. This would occur due to normal development in the town and the effect of the mine population would be to worsen an already overloaded system.

If a new treatment works were to be constructed then, if designed as described, the effect of the in-migrant workforce will be to bring forward any proposed further augmentation of the system. As a proportion of future sewage loadings then by the year 1998 in-migrant mineworkers with a loading of 252EP represents 6% of the total loading to a 4000EP sewage treatment plant.

REFERENCES

- ABS (1982)  
Internal Migration Between 1976 and 1981 by Local Government Areas  
(Cat. No. 2202.1).
- ABS (1986)  
Census of Population and Housing, Small Area Statistics
- Croft & Associates Pty Ltd (1982)  
Dartbrook Environmental Studies
- Croft & Associates Pty Ltd (1984)  
Environmental Impact Statement for Hunter Valley No 2 Mine,  
Warkworth, NSW
- Department of Main Roads  
"Traffic Volumes and Supplementary Data - 1984 Central Western  
Division".
- Graham, P. and Collins, J. (1981)  
The Needs and Characteristics of Persons Living in Temporary  
Accommodation, Muswellbrook.
- McNair Anderson (1980)  
Recent Arrivals to Lithgow, August 1980. Prepared for the NSW  
Department of Environment and Planning.
- Mitchell McCotter & Associates Pty Ltd (1988)  
Environmental Impact Statement for Proposed Mitchells Flat Colliery.  
Prepared for Barix Pty Ltd.
- Mitchell McCotter & Associates Pty Ltd (1988) (in prep)  
Environmental Impact Statement for Proposed Bulga Mine. Prepared for  
The Newcastle Wallsend Coal Co. Ltd.
- National Association of Australian State Road Authorities (1980)  
Interim Guide to the Geometric Design of Rural Roads.
- NSW Combined Colliery Proprietors Association (1981).  
Unpublished data.
- Public Works Department, April 1984  
"Parkes/Peak Hill Water Supply Augmentation (Stage 2) Strategy Study  
Report".

**APPENDIX N**

**CYANIDATION TAILINGS CHARACTERISATION**

Stuart D. Miller & Associates Pty Ltd.

Prepared by:

STUART MILLER & ASSOCIATES PTY LTD

For:

NSR Environmental Consultants Pty Ltd

JANUARY 1989

Peko Wallsend Operations Limited

PARKES PROJECT

APPENDIX N

GEOCHEMISTRY OF OXIDE GOLD TAILINGS

## TABLE OF CONTENTS

	<u>Page</u>
1.0 INTRODUCTION	1
2.0 STUDY APPROACH	1
2.1 Sample Preparation	2
2.2 Testing Programme	2
3.0 RESULTS AND DISCUSSION	3
3.1 Acid Forming Potential of Tailings Solids	3
3.2 Total Element Composition of Tailings Solids	3
3.3 Tailings Liquor and Fate of Cyanide	4
4.0 CONCLUSIONS AND RECOMMENDATIONS	6

## LIST OF TABLES

1 Chemical Composition of Tailings Liquor and Solids	Back of Text
2 Elemental Enrichment Factors in Tailings Solids	Back of Text
3 Expected Cyanide Composition of Tailings Liquor	4
4 Tailings Liquor Decant Decay Test Results	Back of Text
5 Entrained Liquor Cyanide Decay Test Results	Back of Text

## LIST OF FIGURES

1 Cyanide Decay in Tailings Decant and Entrained Liquor	Back of Text
2 Solution Copper in Tailings Decant and Entrained Liquor	Back of Text

## 1.0 INTRODUCTION

Peko Wallsend Operations Limited propose to develop three porphyry copper-gold deposits near Parkes in NSW. The Parkes project involves open cut and underground mining and processing of three different ore types; oxide gold ore, oxide copper-gold ore and primary copper-gold ore. The oxide gold ore will be processed by conventional CIP treatment producing a cyanidation tailings. The oxide and primary copper-gold ores will be treated by froth floatation producing a concentrate product and floatation tailings.

A project life of 20 years is currently planned producing approximately 60 million tonnes of tailings. The CIP plant will operate for the first 18 months producing only 1.5 million tonnes of cyanidation tailings. The bulk of the tailings will therefore be produced from the floatation circuit and will not contain cyanide.

The investigations outlined in this report address the geochemical characteristics of tailings and provide preliminary recommendations for tailings disposal and environmental management.

## 2.0 STUDY APPROACH

The overall objective of this investigation was to determine the geochemical characteristics of tailings and provide the engineering implications for tailings disposal and environmental management. The major geochemical concerns addressed are:

1. Potential for acid generation;
2. Occurrence and environmental significance of toxic elements; and
3. Nature of cyanide decay and fate of cyanide in tailings;

Details of the sampling and testing programmes are outlined in this section.

## 2.1 Sample Preparation

Samples of oxide cyanidation tailings pulp from the E22 and E27 Deposits were prepared by Fox Anamet and immediately sent to Stuart Miller and Associates in sealed containers. Each sample consisted of 5 kg of solids and was supplied as a slurry. The ore was milled in a stainless steel laboratory rod mill to prevent iron contamination. The leaching conditions were as follows:

	E22	E27
Grind (% passing 75µm)	80	80
Solids %	45	45
Leach pH	10	10
Hydrated Lime kg/t	1.0	1.9
NaCN addition kg/t	1.3	1.3
NaCN residual %	0.006	0.016

## 2.2 Testing Programme

The tailings solids were analysed for total sulphur, acid neutralising capacity and multi-element content. The multi-element content was determined by a combination of Atomic Adsorption, Optical Emission Plasma Spectrometry and Inductively Coupled Plasma-Mass Spectrometry by Analytical Services (W.A.) Pty Ltd. Total mercury determinations were carried out on these samples by SGS Australia.

The tailings liquor samples were analysed for total cyanide (CNT), weak acid dissociable cyanide (CN-wad), pH, electrical conductivity, SO<sub>4</sub>, Cl, Al, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, Ni, Pb, Sr, V, W, Zn, Zr, Hg, As, Bi, Se, Te and Sb. The cyanide forms were determined by SGS Australia Pty Ltd and the metals and specific ions were determined by Australian Laboratory Services Pty Ltd using ICP methods.

Cyanide decay tests were carried out on both tailings samples to determine the rate of loss of cyanide from supernatant (or decant) and from entrained liquor within the tailings mass.

To determine the cyanide decay from the decant, 2.3 kg of tailings pulp was placed in an open lysimeter exposed to sunlight with supernatant samples collected after 0, 1, 3, 7, 14, 29, 42 and 56 days. The samples were analysed for pH, EC, CNT, CNwad, Fe, Cu, Ni and Zn.

To determine the nature of cyanide decay within the tailings mass, 1 kg samples of tailings slurry were placed in each of 3 completely filled and sealed containers. Each container was sampled sequentially at 15, 29 and 47 days and the entrained liquor was analysed for pH, EC, CNT, CNwad, Fe, Cu, Ni and Zn.

### 3.0 RESULTS AND DISCUSSION

This section presents and discusses the results of the preliminary laboratory investigations. The results are presented in Tables 1 to 5 and Figures 1 and 2.

#### 3.1 Acid Forming Potential of Tailings Solids

The total sulphur content (% S), acid neutralising capacity (ANC) and calculated net acid producing potential (NAPP) are given on Table 1. The acid generating potential of a material is a function of its sulphide sulphur content and its inherent ANC which are used to derive the NAPP. A negative NAPP indicates there is an excess of neutralising capacity and the material is unlikely to generate acid. Whereas a positive value suggests that the material is acid or may generate acid upon exposure.

The results show that both the oxide tailings samples have a low sulphur content and a negative NAPP. These samples are classified as NON-ACID FORMING.

#### 3.2 Total Element Composition of Tailings Solids

The total element composition of the tailings solids are given on Table 1 along with the average crustal abundance for comparison. Table 2 presents the elemental enrichment factors (<sup>1</sup>EEF) for the tailings solids which are calculated by determining the ratio of the concentration of the particular element in the tailings to the average crustal abundance.

An EEF greater than 5 is considered significant while factors less than this may only reflect analytical and/or natural variability. Values less than 1 indicate that the element is depleted in the sample. Table 2 indicates that Cu, Mo, Cd, As, Sb, Bi and Sn are significantly enriched in both samples, while W and Pb are slightly enriched in the E22 Oxide tailings. Since the oxide gold tailings will be buried by floatation tailings the high level of metals does not pose an exposure hazard. Therefore, these elements will only assume environmental significance if they are able to leach from the tailings into the surrounding environment. Since the tailings are expected to be non-acid forming, the solubility of these elements will generally be low. This aspect is addressed in the next section.

---

<sup>1</sup> EEF values are theoretically calculated after correcting the concentration in each sample with respect to a normally distributed element. This was not possible for the Goonumbla samples since insufficient data is available to identify a normally distributed element in the samples. The EEF values reported here are therefore approximate values only.

### 3.3 Tailings Liquor Composition and Fate of Cyanide

The composition of the tailings liquors are given in Tables 1 and 3. The results indicates that the liquor will be highly alkaline with a pH of 9 to 10 but with a relatively low salinity. Cu, Ni and Zn cyanide complexes occur in the liquor with Cu the dominant metal-cyanide complex. The strong Co complex was also observed in these liquors. All other environmentally important elements such as Hg and As and the enriched elements ( Pb, Mo, Cd, As, Sb, Bi and W) are low and unlikely to be a concern.

The cyanide concentration and cyanide forms are indicated on Table 3. The table shows the concentration of the complexing metal and calculated equivalent cyanide concentration associated with each metal in solution. In both the Endeavour 22 and the Endeavour 27 oxide tailings, Cu is the major complexing metal. A total complexed CN equivalent of approximately 190 mg/l and 30 mg/l is indicated for the Endeavour 22 and the Endeavour 27 oxide tailings liquor, respectively. The expected total cyanide content of the tailings liquor are also shown on Table 3 assuming an excess free cyanide of 100 to 150 mg/l. These total cyanide levels are typical of cyanidation tailings liquor at other operating plants.

The high level of the weak and moderately strong cyanide complexes, particularly Cu, will determine the rate of cyanide decay and cyanide concentration in tailings seepage. The copper complexes have a much slower decay rate than free cyanide and can persist in entrained liquor for a long period thus contributing to seepage.

Table 3: Expected Cyanide composition of Tailings Liquor

	Endeavour 22		Endeavour 27	
	'Oxide' Tailings		'Oxide' Tailings	
	Complexing Metal (mg/l)	CN * Equivalent (mg/l)	Complexing Metal (mg/l)	CN * Equivalent (mg/l)
Fe	<0.01	0	<0.01	0
Cu	153	188	18.9	23.2
Zn	0.27	0.43	2.89	4.60
Ni	0.57	1.06	0.61	1.14
Complexed CN		189.5		28.9
Allow Free CN		100 - 150		100 - 150
TOTAL EXPECTED CYANIDE		285 - 340		125 - 180

\* Assumed complexes:  $Zn(CN)_4^{2-}$ ;  $Cu(CN)_3^{2-}$ ;  $Ni(CN)_4^{2-}$ ;  $Fe(CN)_6^{4-}$

The results of the cyanide decay tests are shown in Tables 4 and 5 and on Figures 1 and 2. Table 4 and Figure 1 give the results for simulated decant decay and Table 5 and Figure 2 give the results for the entrained liquor decay.

As indicated in Table 3, the initial cyanide concentration will most likely be higher than shown on Figures 1 and 2 due to additional free cyanide. However, the results suggest that within 72 hours of exposure the free cyanide will be volatilized from solution. On the other hand, the complexed cyanides are stable and decay at a very slow rate. The results show that after 42 days the concentration of cyanide in the E22 and E27 oxide tailings decant liquor was 78 and 9 mg/l, respectively. The nature of the decay curve indicates that long term decay will continue at a slow rate. The entrained liquor contained 112 and 55 mg/l cyanide in the E22 and E27 oxide samples at day 47.

The residual copper concentrations in decant liquor and entrained liquor are indicated on Figure 2 and confirm that copper-cyanide complexes occur. The pH of the solutions at day 42 and 47 for the decant and the entrained liquors ranged from 8.3 to 9.1.

The results of the cyanide decay test work suggest that the rate of decay of the copper cyanide complex ions in the decant and entrained liquor will be slow and relatively high residual levels of CN and Cu will persist in the tailings liquor. These results are worst case estimates since the decay test work was carried out in the absence of sunlight. Additional decay will occur in the field resulting in lower concentrations. However, even though additional decay is likely to occur in the field, the cyanide and copper levels in tailings seepage will remain elevated and will be an environmental concern if seepage or decant water escapes from the tailings impoundment or is available to livestock and wildlife.

#### 4.0 CONCLUSIONS AND RECOMMENDATIONS

The results of the tailings geochemical investigations indicate that the oxide gold tailings will be non-acid forming but are expected to contain a high residual level of copper-cyanide complexes. The decant liquor and seepage from the tailings storage could contain up to 100 mg/l cyanide and up to 150 mg/l of copper. These concentrations are a potential hazard to wildlife and stock. Wild life and stock must therefore be excluded from the tailings storage area and any seepage through the tailings embankment must be collected and treated to destroy the cyanide. Seepage through the underlying clays is not expected to be a concern due to the very low natural permeability of the clays as well as the low vertical permeability of settled tailings.

Since the tailings storage area is large, it is recommended that the oxide-gold tailings are deposited sub-aerially in 150 to 200 mm beaches. The beaches should be exposed as long as possible to evaporate entrained liquor and maximize cyanide decay.

The recommendations and conclusions presented here are based on the testing of only 2 tailings samples and must be considered preliminary. The geochemistry and fate of cyanide in the tailings during the initial operating period should be further examined and the operation modified, if required, to ensure that long term seepage will not be a concern.

Table 1: Chemical Composition Of Tailings Solids And Liquors

SAMPLE	E22-Oxide	E27-Oxide	E22-Oxide	E27-Oxide	Average
DESCRIPTION	Liquor		Solids		Crustal
PARAMETER	mg/l	mg/l	mg/kg	mg/kg	Abundance*
TOTAL S (%)	-	-	0.12	0.05	260
ANC (%CaCO3)	-	-	1.32	2.60	
NAPP (%CaCO3)	-	-	-0.9	-2.4	
pH	9.2	9.9	-	-	
EC (dS/m)	1.15	1.22	-	-	
TOTAL CN	-	-	36	12	
WAD CN	222	114	-	-	
COMPLEX CN	190	85	-	-	
SO4	101	111	-	-	
Cl	387	339	-	-	
Ca	34.2	19.8	1800	3800	41000
Mg	15.8	2.53	4100	6300	23000
Na	322	287	2800	6100	23000
K	4.78	1.72	15000	7000	21000
Ba	0.05	0.05	660	710	500
P	-	-	640	580	1000
B	0.01	0.04	-	-	
Al	0.03	<0.01	6.5%	7.4%	82000
Fe	<0.01	<0.01	3.2%	5.4%	41000
Mn	<0.01	<0.01	940	960	950
Cu	153	18.9	2100	2000	75
Zn	0.27	2.89	80	45	50
Ni	0.57	0.61	180	240	80
Pb	0.04	<0.01	90	40	14
Co	0.06	0.24	20	50	20
Mo	0.21	0.19	45	56	1.5
Cd	<0.01	0.01	6.5	1.0	0.11
Cr	<0.01	<0.01	240	320	100
As	0.014	0.021	170	12	1.5
Hg	<0.001	<0.001	0.055	0.012	0.05
Sb	0.011	<0.001	8	4	0.2
Se	<0.001	0.001	<10	<10	0.05
Te	<0.001	<0.001	<2	<2	0.005
Be	<0.01	<0.01	3.1	3.0	2.6
Bi	<0.001	<0.001	9.1	3.4	0.048
Sr	0.24	0.24	370	390	370
V	<0.01	0.08	200	280	160
W	<0.01	<0.01	7.3	3.3	1
Zr	<0.01	<0.01	82	82	190
Sn	-	-	1900	23	2.2
U	-	-	9.8	2	2.4
Th	-	-	4.8	7.1	12
Cs	-	-	3	1.7	3
Ce	-	-	52	70	68
La	-	-	21	39	32
Rb	-	-	7	3.2	90

Table 2: Elemental Enrichment Factors (EEF's)  
For The Goonumbla Tailings Solids

SAMPLE	(E22)	(E27)
DESCRIPTION	Oxide	Oxide
S	0	0
Ca	0.04	0.09
Mg	0.2	0.3
Na	0.1	0.3
K	0.7	0.3
Ba	1	1
P	0.6	0.6
Al	0	0
Fe	0	0
Mn	1	1
Cu	28	27
Zn	2	0.9
Ni	2	3
Pb	6	3
Co	1	3
Mo	30	37
Cd	59	9
Cr	2	3
As	113	8
Hg	1	0.2
Sb	40	20
Be	1	1
Bi	190	71
Sr	1	1
V	1	2
W	7	3
Zr	0.4	0.4
Sn	864	10
U	4	0.8
Th	0.4	0.6
Cs	1	0.6
Ce	0.8	1
La	0.7	1
Rb	0.66	1.22

Table 4: Tailings Liquor Decant Decay Test Results

SAMPLE CODE	CUMM. TIME (DAYS)	pH	E.C. (dS/m)	WAD CN (mg/l)	Fe (mg/l)	Cu (mg/l)	Ni (mg/l)	Zn (mg/l)
Endeavour 22 - "Oxide" Tailings								
E22/DD1	0	9.2	1.18	149	<0.01	153	0.57	0.27
E22/DD2	1	9.1	1.14	127	-	-	-	-
E22/DD3	3	8.8	1.17	111	-	-	-	-
E22/DD4	7	8.6	1.19	103	-	-	-	-
E22/DD5	14	8.4	1.12	90	-	155	-	0.03
E22/DD6	29	8.3	1.35	82	-	157	-	0.04
E22/DD7	42	8.5	1.78	78	<0.01	145	0.19	0.09
E22/DD8	56	8.7	1.87					
Endeavour 27 - "Oxide" Tailings								
E27/DD1	0	9.9	1.07	114	<0.01	18.9	0.61	2.89
E27/DD2	1	9.8	0.97	41	-	-	-	-
E27/DD3	3	9.4	1.01	26	-	-	-	-
E27/DD4	7	8.8	1.01	21	-	-	-	-
E27/DD5	14	8.4	1.01	11	-	20	-	0.22
E27/DD6	29	8.2	1.11	10	-	15	-	0.05
E27/DD7	42	8.3	1.37	9	<0.01	7	0.37	0.13
E27/DD8	56	8.6	1.44					

Table 5: Entrained Liquor Decay Test Results

SAMPLE CODE	CUMM.TIME (DAYS)	pH	E.C. (dS/m)	WAD CN (mg/l)	Fe (mg/l)	Cu (mg/l)	Ni (mg/l)	Zn (mg/l)
Endeavour 22 "Oxide"- Tailings								
E22/Initial	0	9.2	1.18	149	<0.01	153	0.57	0.27
E22/EL15	15	9.3	1.36	120	0.3	162	0.56	0.04
E22/EL28	29	8.8	1.15	118	0.2	151	0.56	0.06
E22/EL47	47	8.5	1.30	112	0.03	154	0.21	0.14
Endeavour 27 "Oxide"- Tailings								
E27/Initial	0	9.9	1.07	114	<0.01	19	0.61	2.89
E27/EL15	15	9.8	1.08	58	0.2	22	0.56	2.18
E27/EL28	29	9.3	0.91	56	1.9	27	0.54	1.98
E27/EL47	47	9.1	1.10	55	<0.01	34	0.34	1.99

Figure 1: Cyanide Decay in Tailings Decant and Entrained Liquor

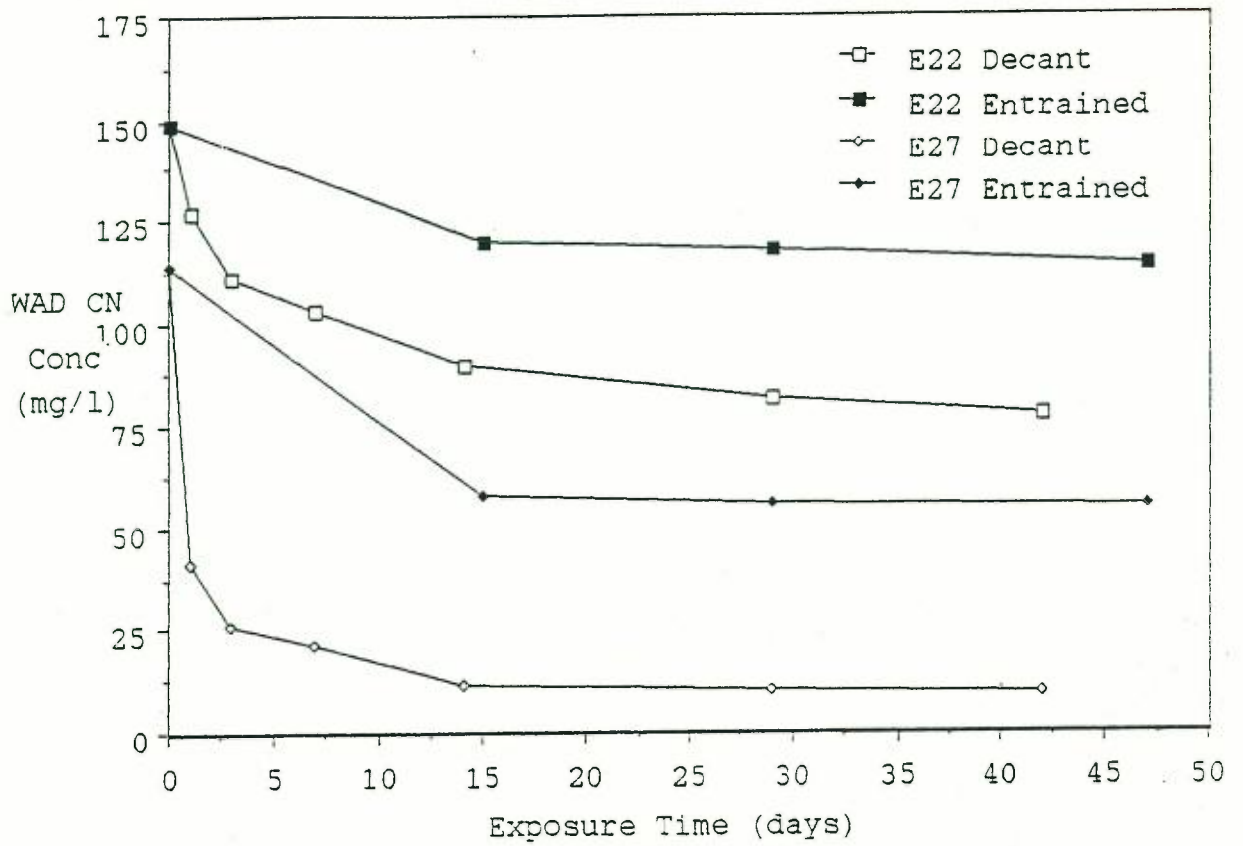
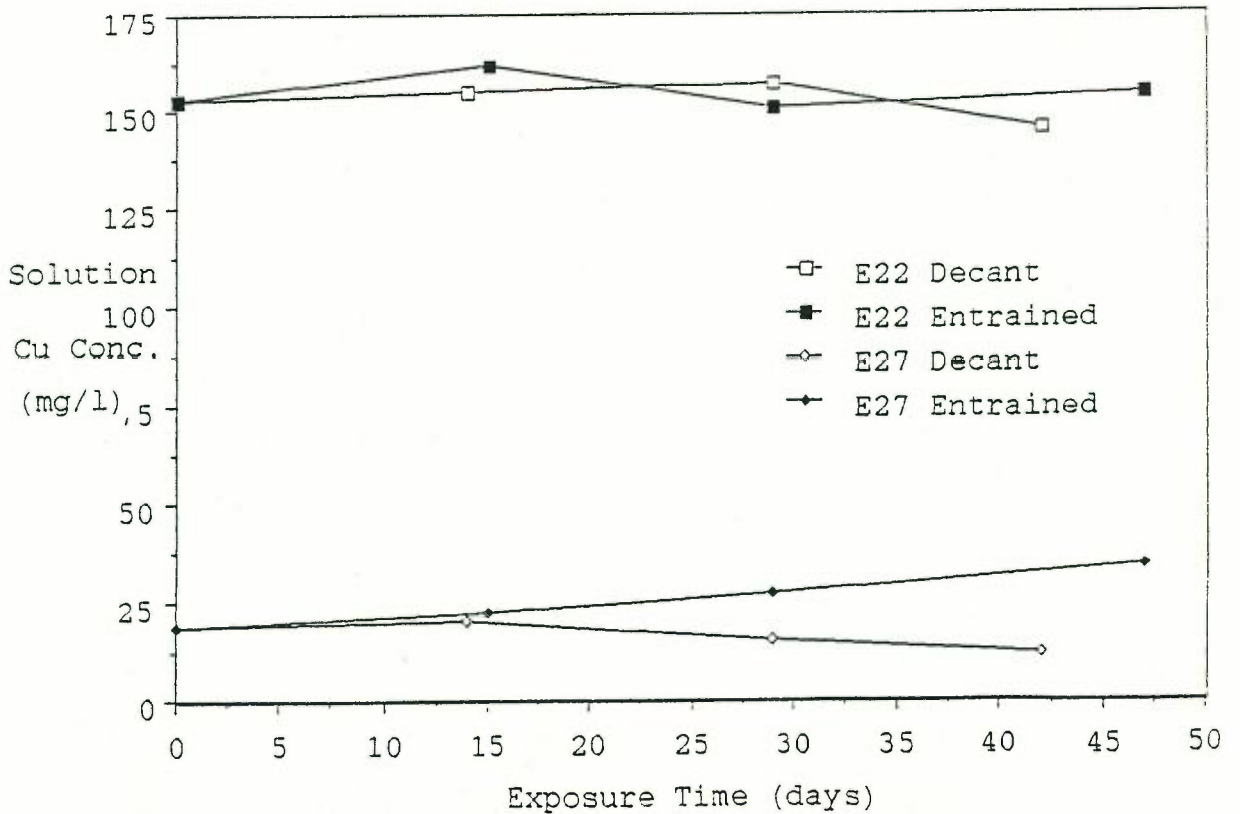


Figure 2: Solution Copper in Tailings Decant and Entrained Liquor



**APPENDIX O**

**TECHNICAL MEMORANDA:**

- (i) DUST GENERATION - MINING ACTIVITIES**
- (ii) BLASTING IMPACT - REVISED CALCULATIONS**

Peko-Wallsend Operations Ltd.

Dust Generation - Mining Activities

Two cases examined (believed to represent worst case).

1. First year of operation, Stage I, includes:
  - Prestrip of E27.
  - Prestrip of E22.
  - Production.
  - Topsoil removal - pits.
    - dump.
    - tailings dam.
  
2. Last year of Stage I, with prestripping for Stage II, includes:
  - Production E27.
  - Extension of E27 pit, say  $6 \times 10^6$  tonnes.
  - Prestrip E26N, say  $12.8 \times 10^6$  tonnes.
  - Topsoil removal, E26N pit and dumps.

Both cases less than REF worst case.

T. Adams, 1/8/88

Case 1

<u>Activity</u>	<u>Max Value</u>	<u>Unit Emmission</u> <u>Factor</u>	<u>Total Annual</u> <u>Dust (tonnes)</u>
1. Topsoil removal	2 scrapers	14kg/scrapper-hour	136
2. Drilling	1800 holes	0.6kg/hole	1
3. Blasting	14 blasts	251kg/blast	3
4. Loading	$6.3 \times 10^6$ t	0.01kg/tonne	63
5. Haulage - in pit	$54 \times 10^3$ veh-km	1.2kg/veh-km	65
6. Haulage - surface	$75 \times 10^3$ veh-km	4.0kg/veh-km	300
7. Dumping	$5.3 \times 10^3$ t	0.02kg/tonne	106
8. Exposed areas	30ha	3.5t/ha/year	105
9. Exposed pits	25ha	1.05t/ha/year	26
10. Exposed tailings	144ha	3.5t/ha/year	504
Max. Total annual dust load			1309

1. Topsoil removal - E22, E27, dumps, stockpiles, tailings dam.

Area	E22	9ha
	E27	16ha
	T.Dam	144ha
	Dumps	<u>48ha</u>
		217ha

Topsoil =  $217 \times 10^4 \times 0.5\text{m}$

->  $1085 \times 10^3 \text{ m}^3$

-> 1 scrapper for 1 year.

Also, some prestrip using scrapper, add 1 scrapper for 1 year.

2. Drilling

Total hard rock, case 1

=  $287 \times 10^3 \text{ t}$

Drill holes, 150t/hole

= 1910 holes.

3. Blasting

Say 20,000t/blast

-> 14 blasts.

4. Loading. Total mined tonnes =  $6.3 \times 10^6$  t  
(from mine production schedule).

5. Haulage, in pit

E27 - 0.45km ->  $45 \times 10^3$  veh-km.

E22 - 0.35km ->  $9 \times 10^3$  veh-km.

$54 \times 10^3$  veh-km.

6. Haulage (assume 50t/truck load).

Material	Surface						Total veh-km( $\times 10^3$ )
	kt	E27 km	veh-km( $\times 10^3$ )	kt	E22 km	veh-km( $\times 10^3$ )	
Ore	995	1.4	39	14	1.9	0.5	39.5
Marginal	327	0.5	3.3	7	0.8	0.1	3.4
Waste	3684	0.3	22.1	1235	0.4	9.9	32.0
Total	5006		64.4	1256		10.5	74.9

7. Dumping

$6.3 \times 10^6 - 1.0 \times 10^6$

=  $5.3 \times 10^6$

8. Exposed Areas

Waste  $4.9 \times 10^6$  ->  $3.5 \times 10^6$  lcm

(approx) -> 25ha

Marginal  $0.33 \times 10^6$  ->  $0.23 \times 10^6$  lcm

-> 3.3ha

-> 30ha total.

Case 2

<u>Activity</u>	<u>Max Value</u>	<u>Unit Emmission</u> <u>Factor</u>	<u>Total Annual</u> <u>Dust (tonnes)</u>
1. Topsoil removal	2 scrapers	14kg/scrapper-hour	136
2. Drilling	23332 holes	0.6kg/hole	14
3. Blasting	195 blasts	251kg/blast	19
4. Loading	19.3x10 <sup>6</sup> tonnes	0.01kg/tonne	193
5. Haulage - in pit	140x10 <sup>3</sup> veh-km	1.2kg/veh-km	168
6. Haulage - surface	170x10 <sup>3</sup> veh-km	4.0kg/veh-km	680
7. Dumping	18.4x10 <sup>6</sup> t	0.02kg/tonne	368
8. Exposed areas	311ha	3.5t/ha/year	1091
9. Exposed pits	53ha	1.05t/ha/year	56
10. Exposed tailings	144ha	3.5t/ha/year	504
Max. Total annual dust load			3229

1. Topsoil

Assume 2 units - prestrip of E26N, + dumps.  
- extension of E27.

2. Drilling

1.5 x 10<sup>6</sup>t from E27 @ 150t/hole -> 10000 holes  
4 x 10<sup>6</sup>t from E27 @ 900t/hole -> 4444 holes  
8 x 10<sup>6</sup>t from E26N @ 900t/hole -> 8888 holes  
23332

3. Blasting

100,000t/blast - 12 x 10<sup>6</sup>t -> 120  
20,000t/blast - 1.5 x 10<sup>6</sup>t -> 75  
195 blasts

4. Haulage - In pit

E27 0.5km -> 55 x 10<sup>3</sup> veh-km  
E26 0.5km -> 85 x 10<sup>3</sup> veh-km  
Total 140

5. Haulage - Surface

Material	E27			E26N			Total
	kt	km	veh-km(x10 <sup>3</sup> )	kt	km	veh-km(x10 <sup>3</sup> )	veh-km(x10 <sup>3</sup> )
Ore	800	1.4	22.4	127	3.0	5.1	27.5
Marginal	200	0.6	2.4	---	---	---	2.4
Waste	500	0.8	8	12700	0.4	67.7	75.7
Total			32.8			72.8	105.6

Plus E27 6x10<sup>6</sup> 0.8 64

Total 169.6 x 10<sup>3</sup> veh-km

6. Dumping

17.4 x 10<sup>6</sup>

7+8. From REF.

9. From Case 1.

## Blasting

### Parameters

Bench Heights	10m	
Blasthole diameter	200mm	
Blasthole Inclination (to vertical)	0°	
Drilled Blasthole length	12m	
Subdrilling	2m	
Assumed Unavoidable fallback	0.4m	
Effective Drilled length	11.6m	
Effective Subdrilling	1.6m	
Stemming length	6.0m	
Charge length	5.6m	(6.0m)
Charge weight	141kg (ANFO)	(150kg)
Drilled Burden	6m	(5.5)
Drilled Spacing	6.9m	(6.3)
Powder Factor	0.34kg/m <sup>3</sup>	(0.43)

Assume max. charge/hole of 150kg.

Recommended firing pattern, 3 charges/delay

-> 450kg/delay.

### Formula

1. Instantaneous resultant of peak particle velocity of ground vibration, V.

$$V = 1143 \left( \frac{\sqrt{W}}{D} \right)^{1.6}$$

W = maximum charge/delay in kg.

D = blast to residence distance in m.

2. Peak airblast overpressure, dBL.

$$\text{dBL} = 162.7 - 19.9 \log \left( \frac{D}{\sqrt[3]{W}} \right)$$

D in feet

W in pounds

Table

Revised Figures for Peak Particle Velocity  
and Peak Airblast Overpressure

Blast to Structure Distance (m)	Instantaneous Resultant of Peak Particle Velocity (from Formula One) (mm/s)	Peak Airblast Overpressure (from Formula Two) (dBL)
500	7.3	116.4
750	3.8	112.9
1000	2.4	110.4
1250	1.7	108.5
1500	1.3	106.9
1750	1.0	105.6
2000	0.8	104.4
2250	0.7	103.4
2500	0.6	102.5
2750	0.5	101.7
3000	0.4	100.9
4000	0.3	98.4

**APPENDIX P**  
**RADIOTELESCOPE INTERFERENCE STUDY**

S. Howard  
Tain Electronics Pty Ltd.

## APPENDIX P

### RADIOTELESCOPE INTERFERENCE STUDY

#### 1. INTRODUCTION

A future mine and process plant at Goonumbla would be located approximately 21 km from the CSIRO Division of Radiophysics radiotelescope at Alectown, north of Parkes.

Following discussion with CSIRO, it was agreed that a preliminary assessment be made of the order of risk of interference that might be posed by the project.

The approach adopted has been to back-calculate from permissible interference levels at the telescope to the corresponding emissions at the mine site, taking attenuation across the intervening 21 km into account.

This technique suffers from the fact that information on machinery emissions is not available from any manufacturer. However, CSIRO have made measurements at 600 MHz and 1400 MHz of interference radiated at the Woodlawn mine.

#### 2. PATH LOSS

It is understood that the frequencies most susceptible to interference from mining plant are 327 MHz, 610 MHz and 1420 MHz. Continuum observations are made at the telescope, and so allowable interference limits correspond to CCIR (1982), Table 1, column 8.

The radio telescope antenna employs a focal point feed horn about 40 m above ground level, and the horn is treated as an isotropic receiver in evaluating the effect of potential interference sources.

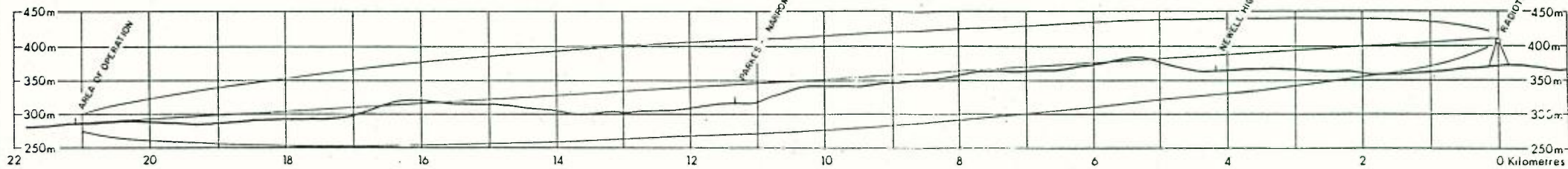
Using the allowed interference limits specified in CCIR Report 224-5 and attenuation over the intervening terrain, it is possible to calculate the limits of emissions permitted from given distant points.

##### 2.1 Terrain profiles

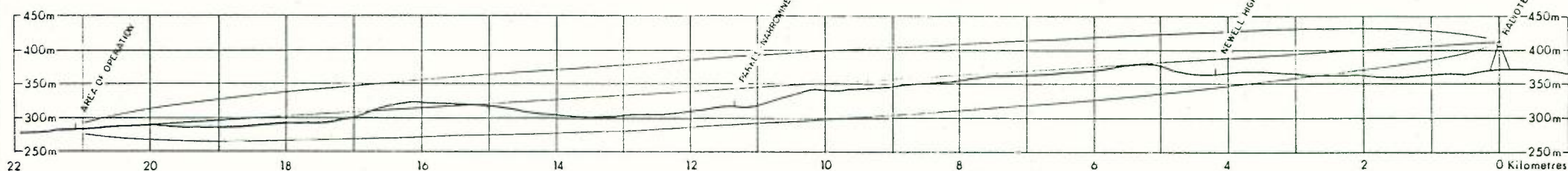
The first Fresnel zone ellipses for three frequencies 327 MHz, 610 MHz and 1420 MHz are shown with the terrain profile as drawn on "4/3 earth curvature" graph paper (Figure 1). These drawings show that:

- The straight line from the elevated radiotelescope antenna to the the mine site passes close to grazing incidence for about 5 km of the 21 km path length.
- Although the sensitive feed horn of the radiotelescope is well above local ground level, higher ground between the Newell Highway and the Parkes - Narromine railway provides useful protection against UHF radiation to within about 5 km of the antenna.

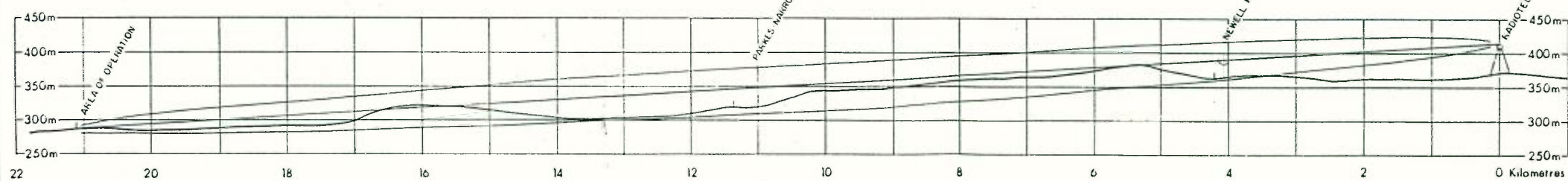
### 327 MHz FIRST FRESNEL ZONE



### 610 MHz FIRST FRESNEL ZONE



### 1420 MHz FIRST FRESNEL ZONE



 Natural Systems Research Pty. Ltd. Environmental Consultants	FIRST FRESNEL ZONES	
	PARKES JOINT VENTURE	
	GONUMLA PROJECT	
Contoured by: [ ] Date: [ ]	FIGURE [ ]	

- At the opposite end of the path, another useful natural obstruction occurs 16 km from the radio telescope.
- Because the electrical plant at the mine is to be located at ground level, local shielding would be practical and effective.
- The principal natural obstacles are relatively close to each end of the path, so that although the terrain barely rises above the direct line of sight, the diffraction loss will be substantial.

## 2.2 Refractive Index

The 4/3 earth curvature diagrams (Figure 1) used to depict the path clearance apply to standard atmospheric conditions. Propagation of ultra high frequency radio waves is influenced by changes in the refractive index of the lower atmosphere. The principal determining factor in the atmospheric refractive index equation is the water vapour content. Consequently, dramatic changes can occur in radio propagation over the sea, and sometimes in coastal regions where anomalous water vapour gradients can develop. Conversely, extreme refractive index structures have been encountered over flat, treeless inland plains when moist air settles over dry air at ground level, causing strong "subrefraction". Here, an effective earth radius of much less than the true physical radius of the earth causes an earth bulge phenomenon, leading to much greater path loss than normal.

However, neither of these gross effects would be expected to occur in the Parkes area. The minor changes in refractive index structure which could be anticipated would have no noticeable effect on this path because the natural obstructions are relatively close to the ends of the path, rather than at the centre, where refractive index changes have the greatest effect on path geometry.

## 2.3 Attenuation Estimates

Calculation of the attenuation for an obstructed path of this nature takes into account both diffraction and scattering. Diffraction theory alone predicts ever-increasing attenuation as clearance is reduced. However, transmission due to scattering by atmospheric irregularities means that total attenuation will not reach the values predicted by diffraction theory. The effect of scattering is difficult to calculate precisely.

## 2.4 Diffraction

Figure 1 shows that the line of sight is twice obstructed by the terrain. A ready approximation of the effect of these features as isolated obstructions can be made from the Bullington knife-edge method, although this will under-estimate the diffraction loss. The loss figures are shown in Table 1.

**TABLE 1 Summary of Path Losses and Emission Levels**

Freq.	Wave Length	Free Space Loss	Path Loss	Input Pwr. Max	Output Pwr. Max
MHz	m	dB	dB	dBW	dBW
327.0	.917	109.2	169.2	-201.0	-31.8
610.0	.492	114.6	169.6	-202.0	-32.4
1 420.0	.211	121.9	171.9	-205.0	-33.1

### 2.5 Goonumbla - Attenuation Path Loss Estimates

Addition of the path loss (i.e. free space loss plus estimated diffraction loss) to the maximum allowable interference input power (from CCIR 1982) gives the maximum allowable isotropic emission at each frequency, at the mine site ('maximum output power' in Table 1).

These final values, in the range -60 dBW to -75 dBW, are well below the levels of incidental RF emission from heavy electrical machinery. Measurements by CSIRO at the Woodlawn mine in 1981 recorded emissions at 600 MHz in the range -41 dBW to -47 dBW.

If the equipment used at Goonumbla were similar to that used at Woodlawn, shielding of the plant would be needed to provide additional attenuation of 27 to 34 dB.

## 3. EMISSIONS AND PRECAUTIONARY MEASURES

The elements of electrical plant known to generate radio frequency noise are:

- High voltage power lines - principally insulator breakdown caused by dust and moisture.
- Large motors - particularly DC commutator types.
- Thyristor switching equipment for motor speed control.

For Goonumbla, all large motors driving crushers, pumps, feeders and conveyors will be AC constant speed types. Supply voltage is generally 415 V but the largest (1.3 MVA and 3.4 MVA) operate at 11 kV.

No insulator breakdown problems should be expected at 415 V, but 11 kV equipment may require special attention. It is likely that only higher voltage lines require larger insulators. The Electricity Commission has found it necessary to install special insulators on 11 kV lines close to the radiotelescope.

Another electric motor will be required for the winder drive. This is expected to have a capacity of approximately 2 MVA average. Two types are under consideration, an AC thyristor-controlled system or a Ward Leonard set. It is proposed that this equipment will be shielded by waste rock dumps and therefore additional protection may be unnecessary.

#### 4. DISCUSSION

The attenuation of radio waves between the site of the proposed Goonumbla mine and the Parkes radiotelescope is such that emissions of the order of -60 dbW to -75 dbW are detectable at the radiotelescope. The attenuation over the path is made up of:

- free space loss due to distance alone,
- diffraction loss due to obstruction by high ground closer to the Parkes radiotelescope.

Diffraction loss could occasionally be reduced by changes in the refractive index of the atmosphere. Shielding (for example by waste rock dumps) close to the source of emissions is needed to provide the necessary attenuation. Such shielding would also minimise atmospheric scatter transmission.

Neither the likely levels of UHF radio emissions from the Goonumbla plant, nor from any comparable installation are known.

High voltage power lines around the Parkes radiotelescope no longer produce interference since the Electricity Commission began using oversize insulators. Further details of relevant installation practice will be sought, to determine any implications for EHT equipment proposed for the Goonumbla plant.

With the combination of attenuation over the intervening terrain, use of constant speed AC motors and oversize insulators, and adequate shielding of electrical machinery at the mine area, it is inferred that there is little likelihood of the emissions from the project being so great as to cause the permissible limit at the telescope to be exceeded.

**APPENDIX Q**

**GROUND VIBRATIONS PRODUCED  
BY UNERGROUND BLASTS**

T.N. Hagen  
Principal and Blasting Engineer  
Golder Associates Pty. Ltd.

The largest blast would break about 1.7 million tonnes of ore and would consume up to about 425 tonnes of explosive. Each explosive charge would weigh up to about 250 kg. Each charge would be initiated by a non-electric delay detonator.

Because all blasts would be underground, air vibrations on the surface would be insignificant.

Before they arrive at ground surface, the ground vibrations generated by a given blast would undergo three-dimensional divergence. Thereafter, Rayleigh (surface) waves would be generated, and these would undergo two-dimensional divergence. Because of the relatively high rate of attenuation of body waves (which diverge in three dimensions), dwellings and structures in the vicinity would experience relatively low ground vibrations. Ground vibrations would also be lowered by the presence of large numbers of free faces (ie, rock/air interfaces) to which charges shoot and from which ground vibrations are reflected.

In view of the above, the following judgement-based equation should be used to predict the ground vibrations produced at various distances from a blast:

$$V = 850 \left[ \frac{\sqrt{W}}{D} \right]^{1.6}$$

where V is the instantaneous resultant of peak particle velocity of ground vibration expressed in millimetres per second,

W is the maximum charge weight per delay expressed in kilograms, and

D is the blast-dwelling distance expressed in metres.

Using a maximum allowable ground vibration of 5 mm/s (this being 50% of that recommended in Australian Standard AS2187, Part 2, 1983), the maximum charge weights per delay at various distances from a 1.7 million tonne blast are as shown in Table 1. This table also shows the number of delays that would be required for a blast which consumes 425t of explosives.

Because there are up to 30 delays in the millisecond series of NONEL or PRIMADET-type detonators, it would be relatively easy to maintain ground vibrations below 5 mm/s for blast-structure distances of about 3.0 km and greater. As the blast-structure distance decreases below about 3.0 km, it would become necessary to use a "piggy-back" initiating system in which the "transmission" lines to some detonators are initiated after the earliest-firing charges have detonated. As more and more "piggy-backing" is carried out, the probability of an initiation malfunction increases and, therefore, there is even greater need for experienced blast design effort.

A moderate amount of piggy-backing would enable ground vibrations to be kept below 5mm/s at

- . "Hopetoun" and "Rosedale" (both 2.7km from blasts)
- . "Rocklands" (2.5km from blasts)
- . "Beechmore" (2.3km from blasts).

Considerable difficulty would probably be experienced in keeping vibrations at "Altona" (located 1.4km from blasts) below 5mm/s.

6789.doc

TABLE 1

Initial predicted maximum charge weights per delay in order to comply with a ground vibration limit of 5mm/s

Blast-structure distance	Maximum charge weight per delay	Required number of delays
1.4km	3.2t	133
1.6	4.2	102
1.8	5.3	81
2.0	6.5	66
2.2	7.9	54
2.4	9.4	46
2.6	11.0	39
2.8	12.8	34
3.0	14.7	29
3.2	16.7	26
3.4	18.8	23
3.6	21.1	21
3.8	23.5	19
4.0	26.1	17
4.2	28.7	15
4.4	31.5	14
4.6	34.5	13
4.8	37.5	12
5.0	40.7	11

**APPENDIX R**

**BOGAN ROAD STUDY**

Fluor Daniel Australia Limited

**PARKES PROJECT**

**BOGAN ROAD STUDY**

**FOR**

**PEKO-WALLSEND OPERATIONS LTD**

**FLUOR DANIEL AUSTRALIA LIMITED  
AUGUST 1990**

## TABLE OF CONTENTS

1.0	INTRODUCTION
2.0	CONCLUSIONS
3.0	CRITERIA
4.0	EXISTING ROAD
5.0	TRAFFIC DENSITY
6.0	ROAD UPGRADE
7.0	MAINTENANCE
8.0	COST ESTIMATES
9.0	REFERENCES

APPENDIX

## DISCLAIMER

"In arriving at estimates contained herein, specialised estimating techniques may have been applied to information not within Fluor Daniel control. While it is believed that the estimates contained herein will be reliable under the conditions and subject to the qualifications set forth herein, Fluor Daniel does not warrant or guarantee the accuracy of such estimates or other information contained therein. The use of such estimates and information shall be at the user's risk and shall constitute a release and agreement to define and indemnify Fluor Daniel from and against any liability in connection therewith, whether arising out of Fluor Daniel's negligence or otherwise".

## 1.0 INTRODUCTION

Peko-Wallsend Operations Ltd (Peko) propose to develop a copper-gold mine near Parkes in central New South Wales. Most of the traffic generated by the mining activities will travel from Parkes to the mine site via existing roads, namely the Newell Highway and the Bogan Road. Concentrates will be trucked to a railway siding at Coonumbra on the Bogan Road.

This report examines the adequacy of the existing Bogan Road to handle the increased traffic and its effect on the life and maintenance of the road.

A previous report by Mitchell McCotter and Associates (MMA) titled "Parkes Copper-Gold Project, Social and Physical Infrastructure, Report", subsequent costing and minutes of meetings with Parkes Shire offices have been reviewed and used where appropriate. This report should be read in conjunction with the above.

However, it should be noted that the MMA report does not use the same terminology to describe the development of the project as is used in the Final Feasibility Study (FFS) and this report. The MMA report refers to phases 1 and 2 of the project while the FFS and this study refer to:

- Stages 1 and 2 - oxide gold and oxide copper/gold ore treated at 3000 t/d
- Stage 3 - sulphide ore treated at 1000 t/d.

## 2.0 CONCLUSIONS

The existing Bogan Road is a good rural road in good condition, the mine operations will however generate traffic which will have an effect on the road between the Goonumbla siding turn-off and the mine site:

- For Stages 1 and 2 of the project the road can be considered suitable with some widening of the shoulders and culverts.
- For Stage 3 of the project the road should be widened to a sealed width of 6 m with 1.5-2.0 m shoulders. In addition some sections of the road require an asphalt overlay.
- Maintenance costs will increase over present costs to about \$50 000/year as the costs attributed to the mining operation increase to 70%
- The cost of upgrading the road to accommodate the extra traffic generated by the mine is estimated to be:

Stage 1 and 2 - \$150 000 all project cost.

Stage 3 - \$845 000 of which about \$726 500 would be the project's share, some of which may be deferred to later years.

### 3.0 CRITERIA

The criteria which must be considered in evaluating the suitability of the existing road are:

- Its capacity to carry the additional traffic generated in a safe manner.
- The ability of the roadway in terms of its strength to carry the increased loads.
- The effect of the increased loads on the life of the road pavement, surface seal and the increased maintenance required.

Road carrying capacity depends on the traffic density, the number of vehicles per hour, or per day, using the road, the road width, alignment and condition of the road surface.

The strength of the road depends on the pavement structure (base and sub-base) conditions, the thickness of the various materials used in its construction and length of time it has been in service.

The useful life of the surface seal is dependent on the amount of heavy loads which it carries and also on the thickness of the seal and the duration it has been in service.

#### 4.0 EXISTING ROAD

As previously reported by MMA the existing road is of a good standard with a consistent formation and generally good horizontal and vertical alignment. The long sight distances and surface conditions generally available allow high speed travel (80-100 km/h).

The surface seal appears to be a single coat generally in fair condition and is about 20 years old. Some sections have been resurfaced with some 10 km around Goonumbla being resealed within the last 3 years. A section of approximately 5 km is in poorer condition with edge deterioration. The seal width is generally 5.2 to 5.4 m, giving a lane width of 2.6-2.7 m each way. Shoulders are generally 2 m or wider except in areas of fill where they are mostly 1 m.

There are no long term traffic counts available but MMA estimated that the Average Annual Daily Traffic (AADT) to be between 100-300 two way traffic.

In April 1989 the Shire installed a traffic counter and initial results show the total vehicles per day to be between 120 and 130 each way, ie AADT of 240-260. The Shire has also carried out an 8 hour survey to determine the types of vehicles using the road. Although one survey of this type is of limited use as it does not allow for seasonal variation, it provides an initial figure as a basis for study. The survey was carried out between 7.30 am and 3.30 pm on Wednesday, 3 May 1989. The day chosen was mid-week, Wednesday and was chosen to represent a typical day as there were no sales in the locality and it is not a traditional shopping day.

The results were:

	South Bound	North Bound	Total
Cars	71	55	126
Rigid Trucks	3	5	8
Articulated Trucks	4	3	7
Tractors	1	2	3
Buses (School)	2	1*	3
Motor Bikes	1	0	1

\*Second school bus had not passed by 3.30 pm.

Typically about 75% of trips are generated between 7 am and 7 pm on rural roads and approximately 50% between the hours of the above survey. The above results show 148 vehicles or 59% of the AADT.

Heavy vehicles (trucks and buses) number 18 or 12% of the total.

For the purpose of this study it is assumed that all heavy vehicles travel between 7.00 am and 7.00 pm daily. On this basis then the total heavy vehicles per day will then be increased by the ratio

$$\frac{250 \times 0.75}{148} \text{ or } 1.26$$

Therefore:

Rigid Trucks	8 x 1.26	=	10 or	10
Articulated Trucks	7 x 1.26	=	8.8 or	9
Buses				<u>4</u>
				23

A significant portion of the seasonal truck traffic is associated with the wheat silos at Goonumbla which handled 2500 t in 1987 and 1988. Most truck payloads occur in the 7-10 t range representing 300 truck movements or 6 per day over two months.

It can be assumed that the road has been designed and constructed to allow for vehicles up to the existing legal limit (axle loads) and as the proposed traffic generated by the mine will be within these limits, road strength should be adequate. The Shire has engaged the DMR to carry out deflection tests (Benkelman Beam tests) on the road to determine the relative condition of the pavement. Although these tests are not conclusive in themselves as to the strength of the road, they are useful in detecting variations and identifying "soft spots" (see Section 6.0).

## 5.0 TRAFFIC DENSITY

Mine traffic is generated by the workforce, deliveries to the mine and transport of concentrates. For the purpose of estimating traffic flow, it has been assumed that the majority of the workforce will live in Parkes and that all vehicles delivering to the mine will be routed through Parkes. During Stage 1 of the project, 1 carload/week of gold concentrate will be produced. During Stages 2 and 3, only gold/copper concentrate will be produced and trucked to the Goonumbla rail siding, the number of truckloads required per week will rise from 25 in Stage 2 to 90 in Stage 3.

Workforce generated traffic is associated with shift changes and result in slugs of traffic in either direction, but at staggered times as the incoming shift will arrive prior to the outgoing shift leaving. The day shift which employs about 65-75% of the workforce in each phase will be the dominant trip generator.

The traffic generated by the mine, based on a five day week, was calculated using the MMA figure of 2.2 occupants per car and assuming that 65% of the total workforce to be on day shift, is shown in the following table 1.

TABLE 1

Stage	Workforce		No. of Cars Each Way		Number of Truck Deliveries per Day	Concentrate Truck Trips per Day
	Total Number	Day Shift Number	Daily	Day Shift		
1	120	78	55	36	5	-
2	120	78	55	36	5	5
3	240	156	110	71	5	18

### 5.1 Traffic Increase

Assuming the existing traffic of 250 vehicles/day of which 23 are trucks and there is no natural increase in traffic then the increase due to the mine will be as shown in Table 2.

**TABLE 2  
TRAFFIC INCREASE  
(Trips/day, 2 way)**

Stage	Present Traffic/Day		Mine Traffic/Day			Future Total Traffic/Day		
	Total Vehicles	Trucks	Total Vehicles	Trucks Total	Trucks Concs	Total Vehicles	Trucks Total	Trucks Conc
1	250	23	120	10	-	370	33	-
2	250	23	130	20	10*	380	43	10*
3	250	23	266	46	36*	516	69	36*

Table 3 shows the % increase in the AADT and the % of AADT attributed to the project.

**TABLE 3  
ROAD USE CHANGES**

Stage	% Road Use by Mine Traffic			% Increase in Road Use		
	Total	Trucks		Total	Trucks	
		*	**		*	**
1	32	30	30	48	43	43
2	34	47	30	52	87	43
3	52	67	30	106	200	43

\* Mine site to Goonumbla rail siding turn-off.  
 \*\* Rail siding turn-off to Newell Highway.

Clearly, the impact of the project on the section of Bogan Road between the mine site and the rail siding at Goonumbla will be greater than on the section between Goonumbla and the Newell Highway, as the latter will not be used for concentrate transport.

## 5.2 Road Capacity

The capacity of a road and the determination of lane width for a given traffic volume are affected by a number of factors. Those specified by National Association of Australian Road Authorities (NAARA) and considered by MMA are:

- Traffic volume
- Vehicle dimensions
- Speed environment
- Combination of speed and traffic volume.

The capacity of a road can be determined from NAARA, Guide to Traffic Engineering Practice, which gives the maximum capacity of a road (2 way) as 2 000 vehicles per hour and then determines the service volume (SV) by applying factors to correspond with:

- level of service of the road
- lane and shoulder width
- design speed
- terrain
- sight distance
- truck content.

Using the formula  $SV = 2000 \times V/C \times W \times T$

where  $V/C$  = volume capacity ratio  
 $W$  = lane width and lateral clearance factor  
 $T$  = truck adjustments factor.

Assume level of service B, stable flow at operating speed of 80 km/h, and sight distance of 450 m for 80% of the time,  $V/C = 0.35$ .

For lane width of 2.7 m and shoulder 1 m  $W = 0.73$  and a truck content of 10.7% for Stage 1 and 2 and 14.5% for Stage 3 gives  $T = 0.71$  and 0.64 respectively.

Applying the above formula then gives the existing capacity of the Bogan road as:

Stages 1 and 2 = 362 vehicles/hr (2 way) or 181 (one way)  
Stage 3 = 327 vehicles/hr (2 way) or 163 (one way)

Actual peak traffic will occur over a 1 hour period ie at a change of shift. If a total of 16 vehicles is included for all other traffic, then peak traffic generated (2 way) will be:

Stages 1 and 2 =  $(36 \times 2) + 16 = 88$  vehicles/hr  
Stage 3 =  $(69 \times 2) + 16 = 121$  vehicles/hr.

The above calculation shows that the existing road width is adequate for the increased traffic. However, NAASRA in the Interim Guide to the Geometric Design of Rural Roads, table 3.1 recommend minimum lane widths for levels of traffic between 150-500 vehicles/day of 3.0 m in each direction with 1.5 m shoulders.

As most of the mine traffic will be travelling in the same direction at peak periods, it can be argued that the existing road will be suitable for Stages 1 & 2 (with some widening of shoulders to 2.0m). For Stage 3 the road should be increased to a sealed width of 6 m with shoulders of 1.5 m width as recommended.

### 5.3 Road Wear and Life

Generally road pavements are designed for a life of 15 to 20 years before major repairs are anticipated. The final wearing surface or bituminous seal will last 7 to 10 years before a respray is required.

As previously stated the road is about 20 years old and with an expected mine life of 12 years it may be assumed that a major rehabilitation will be required during the mine life if there was no increase in other traffic.

The mine traffic will shorten the expected life of the pavement and the seal due to the increased traffic particularly in heavy vehicles.

The performance or the life expectancy of a road is dependent on a number of factors namely, subgrade strength, pavement materials, climate, drainage and traffic loadings. On a long length of road all these variables may change. The analyses to do a complete evaluation are involved and extensive testing is required. A simplified comparison has been made of mine generated and other traffic to determine the proportion of "wear and tear" applicable to each.

It is well recognised and documented that cars do little damage to a road pavement except wear on the running surface and edges and all the structural damage or deformation is attributed to heavy vehicles. The extent of damage is related to the axle loads and configuration, and is expressed as the number of times an axle passes a fixed point for failure to occur.

The conventional method is to convert all axle loads to Equivalent Standard Axles (ESA) and then apply the formula:

$$\frac{N_s}{N} = \frac{P}{P_s}^4$$

- N<sub>s</sub> = number of passes by a standard axle
- N = number of passes by a non-standard axle
- P<sub>s</sub> = load of standard axle (ESA = 8.2t)
- P = load of non-standard axle.

Since the axle loads on existing traffic or the proposed concentrates truck are not known, the equivalent number of ESA for each type of truck are given in Table 4.

For the existing traffic the following ESA's for each direction can be assigned from Table 4:

Rigid Trucks	2.5 x number of Vehicles	5	=	12.5 ESA
Articulated Trucks	4.2 x number of Vehicles	4.5	=	18.9 ESA
Buses	2.2 x number of Vehicles	2	=	<u>4.4 ESA</u>
				35.8/day

Then for the next 12 years (life of the mine) the number of axle (ESA) passes will be 156,800 ESA.

Assume that the concentrate trucks will be 5 axle articulate or 4.4 ESA, and the remainder will be 50% at 4.4 ESA and 50% at 3.3 ESA's (average 3.85 ESA).

Then the mine will generate over 12 years.

Deliveries	25/wk at 3.85 ESA x 12 years	=	60 060
Concentrates	25/wk at 4.4 ESA x 2 years	=	11 440
	90/wk at 4.4 ESA x 9 years	=	185 328

Mine to Goonumbla	—————	256 828 ESA
Goonumbla to Newell Highway		60 060 ESA

Then total expected traffic loading for the 12 years will be:

Mine to Goonumbla	156 800 + 256 828	=	413 628 ESA
Goonumbla to Newell Highway	156 800 + 60 060	=	216 860 ESA

The calculation shows that over the expected 12 year life of the mine, the traffic associated with it may be responsible for 62% of the wear and damage to the road between the mine and the Goonumbla siding, and 28% between the siding turn-off and the Newell Highway.

These figures may underestimate the effect of traffic generated by mine related activities and to avoid contention it is recommended that an average figure of 70% be used for calculating Peko's contribution to maintenance of the road.

Wear on the running surface, ie the bituminous seal can be similarly calculated approximately the same results, but as the seal coat would have a design life of 7 to 10 years a rescal will be required in the life of the mine.

## 6.0 ROAD UPGRADE

A visual inspection of the road, revealed that the road surface is generally in good condition, as noted in Section 4.

The section from the Newell Highway to the Goonumbla Siding turnoff contains some areas of bitumen surface in poor condition with edge deterioration. About 30% of this length of road is in fill with narrow shoulders and 5 culverts would require substantial earthworks if the road is to be widened.

As previously mentioned some 10 km of the road has recently been resurfaced.

The section from the Goonumbla siding to Trundle Road intersection is situated in flat ground with few embankment shoulders are generally wider and only approximately 1% requiring widening. There are 9 culverts in this section but do not represent a problem if widening is required.

To determine the structural adequacy of the road the Shire organised the Roads and Traffic Authority (RTA) to carry out deflection tests along the road. The method used Benkelman Beam which measures deflections in the surface when subjected to a known axle load. Deflection readings were taken every 500 m on the north bound lane only. These results may then be applied to known relationships to determine permanent deformation for any traffic loading conditions. These relationships can be found in reference publications such as Pavement Design, by NAASRA 1987, chapter 10, Overlay Design.

The test results obtained from the RTA are included as Appendix A. The figures given are in hundredths (1/100) millimetres, not mm as stated. The traffic loading condition required over the 12 years of mine life has been used in the calculations given in 5.3

Following the procedure given in Chapter 10 of above reference and applying figure 10.2 for temperature adjustment to the test results and utilising the corrected figure in figure 10.3 the maximum deflection allowable for permanent deformation not to occur is

1.35 mm for  $2.1 \times 10^5$  ESA (Newell Highway to Goonumbla) and  
1.21 mm for  $4.3 \times 10^5$  ESA (Mine to Goonumbla).

These limits when compared with the test results readings 1 to 27 (Newell Highway to Goonumbla) indicate 7 sections or 3.5 km which may be structurally inadequate over the 12 years. Readings 28 to 48 (Goonumbla to Trundle Road) show 3 sections or 1.5 km which may be inadequate.

The above results should only be taken as a guide as to where problem areas may occur which will require further investigations. It should also be noted the Benkelman Beam readings are influenced by the moisture content in the various materials and that the RCA testing was carried out after a prolonged wet period (May 1989).

If strengthening of the road is required, the most common method is the application of an overlay of granular material or asphalt.

For costing purposes in this report a 50 mm asphalt overlay has been assumed which would typically reduce deflection to about 80% and should cater for the majority of the suspect areas.

It should be noted that this expenditure may be deferred until surface conditions make it apparent that failure is occurring.

## 7.0 MAINTENANCE

Maintenance requirements for a road depend on the type and amount of traffic, climate and the road alignment. The climate of the area is mild and relatively dry, the road alignment is generally good, therefore existing maintenance can be expected to consist of grading the shoulders and clearing out the side drains twice a year which will not be increased greatly by the additional traffic. The need to mend pot holes, edges and surface damage in the suspect areas will increase prior to the road being upgraded and resealed and then should be minimal for the remainder of the life of the mine.

The cost of maintenance has been proportioned directly to the amount of usage by each component, ie normal traffic and mine traffic. Tables 2 and 3 show that for Stages 1 and 2 truck traffic is doubled and for Stage 3 the increase is about 2.6 times over current traffic.

Therefore maintenance costs of 50% in Stages 1 and 2 and 70% in Stage 3 can be attributed to the mine.

## 8.0 COST ESTIMATE

Unit prices estimate given by Mitchell McCotter have been adopted (and increased for 1989 prices):

### Roadworks

#### Stage 1 and 2

(During Construction Period)

	\$	\$
• Widening of shoulders over 5 km @ \$23000/km	115 000	
• Culverts upgrade 5 No @ \$5000	25 000	
• Testing, Design, Supervision, etc	10 000	
		<u>150 000</u>

#### Stage 3

(Prior to Stage 3 Start)

• Additional width of seal 1.0 m single coat for 23 km @ \$3.0/m <sup>2</sup>	69 000	
• Reseal existing surface 5.4 m wide @ \$2.00 m <sup>2</sup> and trim shoulders 2 x \$0.6/m:		
Newell Highway/Goonumbla 14 km @ \$12.0/m	168 000	
Goonumbla/Mine 9 km @ \$12.0/m	108 000	
Extra for 50 mm Asphalt overlay 5 km @ \$90.0/m	450 000	
Plus Contingency (includes design & supervision)	<u>50 000</u>	
<b>TOTAL COST OF ROADWORKS:</b>		<u><b>845 000</b></u>

#### Project Share of Cost:

Stage 1 and 2 @ 100%	150 000	
Stage 3		
Asphalt overlay @ 100%	450 000	
Remainder @ 70%	276 500	
<b>TOTAL PROJECT SHARE:</b>		<u><b>876 500</b></u>

#### Maintenance (per annum)

Maintenance say @ \$2200/km (clean drains, trim edges and shoulders, patch pot holes, supervision) x 23 km	50 000	
--	--------	--

#### Project Share of Cost

Stage 1 and 2 (say 50% share) per year	25 000
Stage 3 (say 70% share) per year	35 000

## 9.0 REFERENCES

- Mitchell, McCotter & Associates - Parkes Copper Gold Project,  
Social & Physical Infrastructure; Report  
NAASRA Guide to Traffic Engineering Practice.  
NAASRA Pavement Design 1987.  
NAASRA Interim Guide to the Geometric Design  
of Roads.  
DMR Pavement Thickness Design.

APPENDIX A

PARKES SHIRE

SHIRE ROAD 76

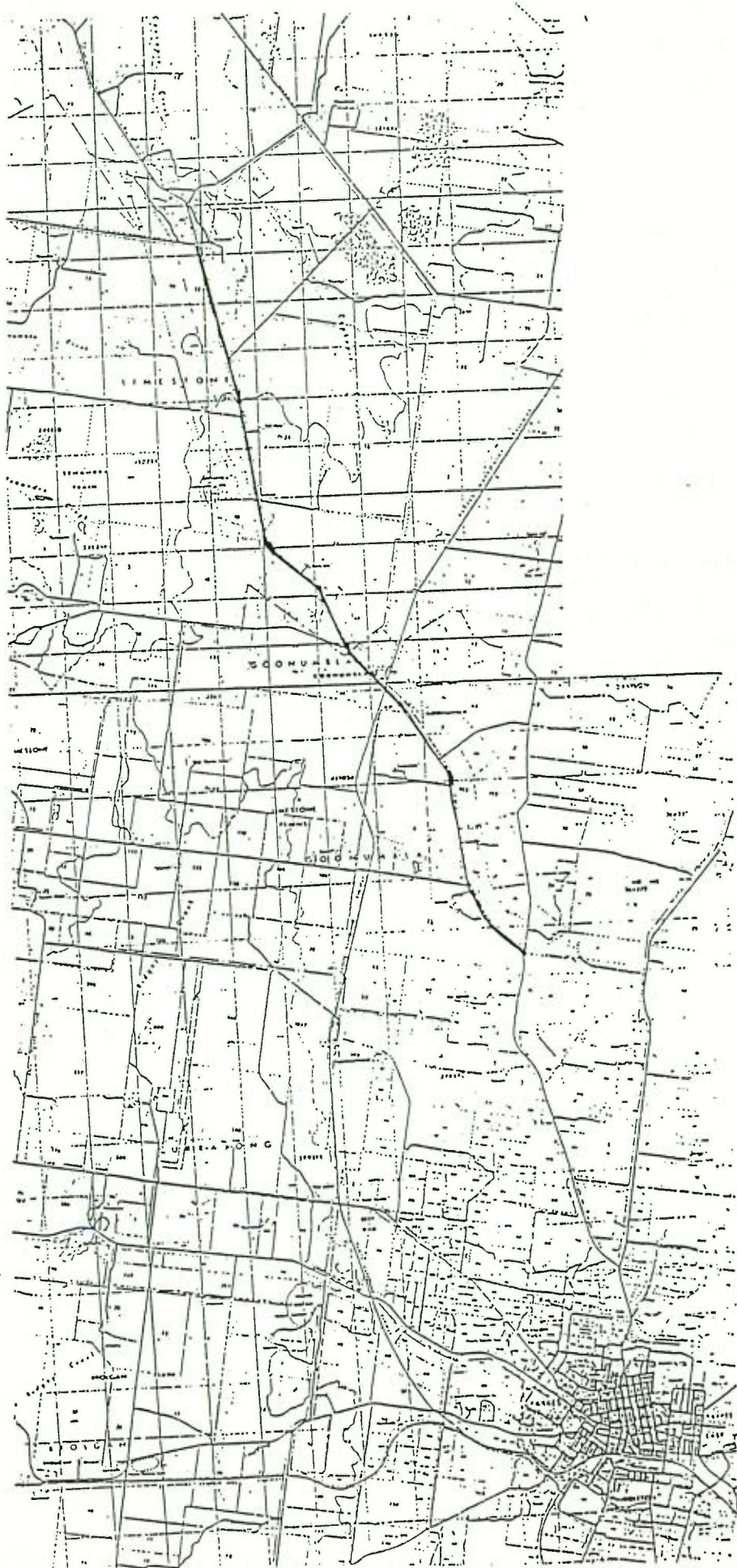
BENKELMAN BEAM

DEFLECTION

TESTING

file 85/a.730

# LOCATION OF WORK



DEPARTMENT OF MAIN ROADS, N.S.W.  
BENKELMAN BEAM DEFLECTION TEST

T160	H.O. File D.O. File 85/A.730 W.O. File Lab No. PB10 Laboratory at PARKES
WORK: <i>Shire of Parkes. Bogan Road.</i>	

SECTION: <i>SH 17 - END OF BITUMEN</i>	Date Tested <i>24.5.89</i>	Sheet 1 of 3
--	-------------------------------	--------------

COURSE: <i>EXISTING BITUMEN</i>	Beam Factor <i>3:1</i>	Temperature: Air Road <i>18°C</i>
---------------------------------	------------------------	-----------------------------------

Chainage	Lane	Wheel Track	Dial Gauge Reading (mm)					Maximum deflection mm	Remarks
			300mm	600mm	900mm	2.7m	9m		
1	north bound	L	11	22	23	25	25	75	
2	"	L	15	30	42	53	53	159	
3	"	L	16	39	46	50	52	156	
4	"	L	15	48	55	56	58	174	<i>Narrow Pit</i>
5	"	L	3	11	13	15	15	45	
6	"	L	12	32	40	43	43	129	
7	"	L	-1	5	9	15	15	45	<i>Rocky Fill</i>
8	"	L	14	29	35	37	47	141	
9	"	L	10	38	47	49	50	150	
10	"	L	-2	3	8	14	14	42	
11	"	L	5	20	22	25	25	75	
12	"	L	8	17	19	20	20	60	
13	"	L	10	22	25	25	30	90	
14	"	L	25	52	61	61	61	183	
15	"	L	25	60	70	72	72	26	<i>Fill Area</i>
16	"	L	0	5	10	16	18	54	
17	"	L	-2	4	10	17	20	60	
18	"	L	15	31	37	45	46	138	
19	"	L	0	1	3	8	10	30	<i>Pvt Good</i>
20	"	L	4	16	19	25	26	78	<i>Pvt Good</i>

Sub-section	Deflection Parameters				Visual Rating	Elastic Theory Parameters		Comments
	Mean Defln mm	Stand Dev. mm	85th Defln mm	Design* Spreadability %		E <sub>s</sub> MPa	D mm	
								Readings taken every 500 m in outer wheel track.

\* Can be derived from mean or 85th Defln. If derived from mean leave 85th Defln. Column blank.

RECOMMENDATION:	SIGNATURE <i>[Signature]</i> DESIGNATION <i>Testing Operator</i> DATE <i>24.5.89</i>
-----------------	--

DEPARTMENT OF MAIN ROADS, N.S.W.  
BENKELMAN BEAM DEFLECTION TEST

T160	H.O. File D.O. File 85/A.730 W.O. File Lab No. PB10 Laboratory at PARKES
WORK: <i>Shire of Parkes. Bogan Road.</i>	

SECTION: <i>SH 17 - END OF BITUMEN</i>	Date Tested <i>24.5.89</i>	Sheet <i>2</i> of <i>3</i>
COURSE: <i>EXISTING BITUMEN</i>	Beam Factor <i>3:1</i>	Temperature: Air Road <i>18°C</i>

Chainage	Lane	Wheel Track	Dial Gauge Reading (mm)					Maximum deflection mm	Remarks
			300mm	600mm	900mm	2.7m	9m		
21	North bound	L	1	17	26	31	32	96	
22	"	L	10	22	26	29	29	87	
23	"	L	5	24	28	29	31	93	<i>Pvt Good</i>
24	"	L	6	21	26	31	31	93	<i>Pvt Good</i>
25	"	L	17	26	27	27	29	87	<i>Pvt Good</i>
26	"	L	39	54	65	71	75	225	<i>Pvt Good</i>
27	"	L	6	23	33	41	45	135	<i>Pvt Good</i>
28	"	L	0	8	12	18	22	66	<i>Goonumbla</i>
29	"	L	1	15	25	30	30	90	<i>Goonumbla</i>
30	"	L	11	29	35	35	38	114	<i>Trundle TO</i>
31	"	L	6	20	28	28	30	90	
32	"	L	5	13	17	19	19	57	
33	"	L	1	16	20	24	27	81	<i>Pvt Good</i>
34	"	L	10	23	27	27	27	81	<i>Pvt Good</i>
35	"	L	7	22	33	45	45	135	<i>Pvt Good</i>
36	"	L	10	25	30	31	31	93	<i>Pvt Good</i>
37	"	L	3	10	12	14	16	48	<i>Pvt Good</i>
38	"	L	5	18	24	24	24	72	<i>Pvt Good</i>
39	"	L	-3	0	2	5	6	18	<i>Pvt Good</i>
40	"	L	10	20	31	31	32	96	

Sub-section	Deflection Parameters				Visual Rating	Elastic Theory Parameters		Comments
	Mean Defln mm	Stand Dev. mm	85th Defln mm	Design* Spreadability %		E <sub>s</sub> MPa	D mm	
								<i>Readings taken every 500 m in outer wheel track.</i>

Can be derived from mean or 85th Defln. If derived from mean leave 85th Defln. Column blank.

RECOMMENDATION:	SIGNATURE <i>[Signature]</i> DESIGNATION <i>Testing Operator</i> DATE <i>24.5.89</i>
-----------------	--



**APPENDIX S**

**OVERVIEW REPORT OF THE COMMISSION  
OF INQUIRY RE SECTION 94**

Commissioners of Inquiry for  
Environment and Planning

Report to the Honourable David Hay  
Minister for Local Government  
and Minister for Planning

An Inquiry pursuant to Section 119 of the  
Environmental Planning and Assessment Act 1979  
with respect to

OPERATION AND PRACTICES ASSOCIATED WITH  
CONTRIBUTIONS UNDER SECTION 94 OF THE  
ENVIRONMENTAL PLANNING AND ASSESSMENT ACT 1979

William Simpson  
Deputy Chairman

COMMISSIONERS OF INQUIRY FOR  
ENVIRONMENT AND PLANNING

October 1989

SYDNEY

OCTOBER 1989

TO: THE HONOURABLE DAVID HAY, MINISTER FOR LOCAL GOVERNMENT  
AND MINISTER FOR PLANNING

An Overview

Report of the Commission of Inquiry Re Section 94  
of the Environmental Planning and Assessment Act 1979

Hearings concerning this matter commenced on 29 May 1989 and concluded 15 August 1989. Some 123 submissions were made to the Inquiry (see Appendix 1).

Applicants seeking approval for "development" have since 1919 been required to "contribute" to the cost of satisfying needs likely to be created by their "development". Initially contributions were confined to land for parks and road construction work. The contribution system expanded over time to include monetary payment, water sewerage and drainage work and since the advent of the Environmental Planning and Assessment Act 1979 "public amenities" or "public services" within the area of the consent authority.

This shift of urban infrastructure funding from the public to the private sector is paralleled in various countries, particularly the United States of America, where similar type "exaction" (Section 94 contribution) systems are in force. It is also evidencing itself in other Australian States particularly in Victoria.

Such changed method of financing urban infrastructure has been occasioned by the high cost of capital, restriction on traditional loan and revenue raising methods, additional cost of servicing public needs and increased expectation re number and standard of amenities and services and a general trend towards the user pays principle.

It is recognised both here and overseas that the validity and integrity of such a contribution system is dependent upon demonstrating that a development is likely to create a need for public amenities or public services, that contributions are for the purpose of satisfying such need, that there is a nexus between need created and need satisfaction measures adopted, that the contribution amount is fair and reasonable and that the consent authority is accountable for the manner in which contributions are spent to satisfy the need created.

Local government contends the above objectives are met by most councils, that Section 94 contributions are an essential element in its budgeting for urban infrastructure and that the absence or restriction of this method of

funding would mean that necessary public amenities or public services would not be provided or would need to be met from already restricted and reduced funding sources to the detriment of other existing local government services.

In general the development industry is opposed in principle to the Section 94 contribution system regarding it as an unfair sectional tax on development. The development industry and certain state government agencies claim many councils are failing to observe the nexus and fair apportionment of cost principles when levying Section 94 contributions and using the system as a general taxing or revenue raising method. Further that funds so secured are not always used for the purpose of satisfying the need occasioned by development.

Various professional organisations including the Royal Australian Planning Institute and the Local Government Planners Association of New South Wales, whilst supporting the need for "upfront" payments by the private sector to finance urban infrastructure, call for increased professionalism in the approach of councils to the operation of the Section 94 contribution system.

I am of the opinion that the Section 94 contribution system must be viewed as a special user pays tax on development. Justification for this tax is dependent upon the taxing authority, here councils, demonstrating that a development creates a need for "public amenities" and/or "public services" and that the tax (contribution) sought is fair and reasonable and for the purpose of satisfying such need.

In such circumstances councils must be and be seen to be accountable not only to demonstrate the nexus concept inherent in the above but also the method by which contributions are assessed and the manner, cost and financial implications of the method they adopt to satisfy the need created (in particular where and when money collected will be spent).

Accountability demands that all such information be available in a document readily and publicly to hand.

In the absence of the abovementioned justification and documentation, contributions sought must be regarded as a disguised form of general tax on development.

I am also of the view (in line with overseas experience, and having regard to the fiscal and public expectation matters adverted to above, the trend of court decisions and the nexus principle), that the number and type of facilities in respect of which Section 94 contributions are sought will continue to expand.

In these circumstances it is imperative that if the Section 94 contribution system is to continue as a publicly acceptable method of financing urban infrastructure and a funding method for local government, steps must be taken to

ensure a more professional approach and greater uniformity and consistency between councils in respect of both the data and the methodology used to assess and compute contributions. Also to demonstrate accountability for funds collected and spent.

As evidenced before this Inquiry there are many councils who have failed to approach their responsibilities re Section 94 contributions in a professional manner. Some have simply adopted the practices of neighbouring councils. Others have assumed development creates a need without appropriate studies in such regard. The Commission has noted instances where contributions are sought for facilities such as open space, community needs, and drainage in the absence of basic studies as to appropriate standards, needs and cost. In other circumstances where said "needs" studies were undertaken, they were found to relate to the need for public amenities and public services on a general municipality or shire wide basis having regard to the population as a whole rather than need likely to be generated by proposed or likely future development requiring consent under the Environmental Planning and Assessment Act.

It should be said however that certain councils (in the main, those concerned with "greenfield" locations and certain provincial cities) have carried out extensive studies and implemented management/structure plans and procedures which properly implement the Section 94 contribution system. Only a few councils concerned with established urban areas can be said to have moved to this degree of sophistication.

Notwithstanding the achievements of certain councils, there remains a necessity for greater consistency between councils as to methods by which the need for facilities are determined, the quantification and financial implications, both short and long term, of the needs satisfaction method adopted and justification of such actions in the public arena.

These circumstances dictate that each council prepare a structure/management plan or plans geared to an implementation program and fiscal strategy to enable efficient, economic and equitable administration of the Section 94 contribution system.

Such plan should emerge as a Development Control Plan (DCP) or plans pursuant to Section 72 of the Environmental Planning and Assessment Act and thus will have regard to the individual needs and characteristics of a local government area.

It is my view and I have so recommended that the Section 94 contribution system being a special type user pays tax should be structured and administered to ensure:

- (i) Need created by development (user) is identified.

- (ii) Measures adopted by the taxing (consent) authority to satisfy the need are defined, quantified and costed and benefit the development concerned.
- (iii) The users contribution (tax) is a fair apportionment of the cost of satisfying the need satisfaction measures adopted by the consent authority.
- (iv) The consent (tax) authority is publicly accountable to demonstrate measures and factors relied upon to determine the contribution and to show how, when and where contribution collected is spent.
- (v) The contribution system is operated in an equitable manner.

Having regard to the above expressed management objectives as emerging from the evidence before this Commission of Inquiry, I answer hereunder the question posed in each of the Commission's five terms of reference and briefly advert to certain of the major recommendations I make in Section 22 of this report.

Should there be a limit as to the type and category for which contributions may be sought?

Yes - Pursuant to a Section 94A direction by the Minister and pending adoption by a council of a satisfactory Section 72 Development Control Plan. (See Sections 12, 14 and 17 of this report)

Should there be a limit on the amount of contributions?

No - To do so would:

- (i) be opposed to the logic (nexus and fair apportionment of cost concepts) which validates and justifies the existence of what is in effect a special user pays tax levied to satisfy the public services/amenities need occasioned by development.
- (ii) fail to have proper regard to cost variables occasioned by differing demographic, land cost and construction circumstances in and between the various local government areas. (See Sections 11, 12, 14 and 18 of this report)

Do contributions increase the price of land?

Yes - Extent of increase is dependent upon cyclic period of land market - generally a marginal increase and not to extent of negating need for such contributions. (See Section 19 of this report)

When should contributions be paid?

Development applications involving subdivisions - at release of linen plans.

Development application involving building work - at time of building approval pursuant to Local Government Act 1919.

Development applications where no building approval required - at time of development consent.

In all of the above type applications deferred payments should be acceptable subject to suitable financial guarantees. (See Sections 11, 14 and 20 of this report)

Should councils be more accountable for the way they spend contributions?

Yes - Publicly available Development Control Plans prepared pursuant to Section 72 of the Act should specify need occasioned by development, measures and time necessary to satisfy same including methodology and formulas used. Information should also be available indicating source of contributions, where, when and for what purpose it was or will be spent. (See Sections 14 and 21 of this report)

I have recommended councils administer the Section 94 contribution system via a Development Control Plan (DCP) as plans prepared and adopted pursuant to Section 72 of the Environmental Planning and Assessment Act. Such an approach will enable the differing economic, social and environmental considerations as between councils to be taken to account.

I have also recommended a "guidelines committee" be established consisting of representatives of local government, development industry, professional groups and state government agencies. This committee is to prepare state guidelines (which have regard to the terms of my report) for use by councils in preparing the abovementioned DCP's. Such guidelines will ensure a consistency of approach by councils in regard to methodology, administration and accountability.

Further that the Minister make a direction pursuant to Section 94A of the Act applicable to all consent authorities restricting the facilities in respect of which contributions may be sought to those recommended by me in Section 14 of this report. Such direction should not specify a maximum contribution amount.

The Minister's direction should specify the methodology approach recommended in Section 12 of this report.

The Minister's direction shall cease to apply to a local government area when that council has adopted a satisfactory DCP.

In Sections 11 and 13 of this report I have canvassed problems arising where development brings about a need for provision of public amenities and public services beyond the boundaries of the consent authority concerned. Also circumstances where development occasions a need for facilities in respect of which it is the responsibility of the State to provide. These matters are also relevant to the State's "1982 State Infrastructure Financing Policy".

All three matters may be appropriately dealt with by an amendment to Section 94 along the following lines and I so recommend:

1. Where the Minister is of the view that a development is likely to create a need for public amenities or public services in an area beyond that of the consent authority concerned, or for such facilities (within or without the consent authority's area) for which the Crown has whole or part responsibility to provide, the Minister may direct the consent authority to levy such contributions as he deems necessary in the circumstances of the case.
2. Such contribution shall be in addition to but not duplicate any contribution a consent authority is enabled to levy pursuant to Section 94.
3. Regulations may be made by the Minister in respect of the type of facilities here concerned, the quantum of contributions, and the manner of disbursement of contributions received in this regard.

I would also particularly direct your attention to:

- (a) Recommendation 16 - concerning the failure of present planning legislation to integrate environmental and fiscal planning.
- (b) Recommendation 19 - financing of public housing.
- (c) Recommendation 20 - judicially sponsored settlement negotiations re Section 94 disputes and Section 121 dispute resolution as between local government and state agencies.

*William Simpson*

WILLIAM SIMPSON  
Deputy Chairman  
Commissioners of Inquiry for  
Environment and Planning

**APPENDIX T**

**MINE-DERIVED DUST INCREMENTS**

NSR Environmental Consultants Pty Ltd.

## Contents

1.0	Introduction	1
2.0	Methods	2
3.0	Results	4
4.0	References	7

## Tables

1	Dust tonnages generated in the northern and southern portions of the operations area	2
2	Distances required for a 2 g/m <sup>2</sup> /month mine-derived increment	4

## Figures

1	Calculated 2 g/m <sup>2</sup> /month mine-derived dust contour	5
---	--	---

# 1.0 Introduction

This report has been prepared in response to concerns which have been expressed about dust levels near the project area and possible adverse effects on residential amenity in the vicinity of the mine. The data presented in Appendix I has been used to model dust concentrations which are likely to occur during the year of maximum activity. These have been used to prepare a 2 g/m<sup>2</sup>/month contour around the active mine area.

## 2.0 Methods

Dust loadings from a variety of activities have been estimated in Table 2, Appendix I. Analysis of this data was based on the conservative assumption that all dust sources could be aggregated as a single point. The current approach has been to divide the operations area into two. Dust loadings have been split on the basis of two thirds being generated in the northern pits and surrounds and one third in the southern pit and surrounds, apart from surface haul roads and other exposed areas which have been split three quarters to the north and one quarter to the south. A breakdown of the tonnages generated is given in Table 1. In terms of the total tonnage of dust generated, three quarters originates from the northern area and one quarter from the southern.

**Table 1**  
**Dust tonnages generated in the northern and southern portions of the operations area**

Activity	Total Annual Dust (t)	Annual Dust from Northern pits/area (t)	Annual Dust from Southern pit/area (t)
Haul Roads			
In-pit	277	185	92
Surface	1562	1171	391
Blasting	19	13	6
Loading	78	52	26
Drilling	3	2	1
Dumping	157	105	52
Exposed areas	1091	818	273
Exposed pits	56	37	19
Exposed tailings	539	539	0
Top-soil removal	68	45	23
<b>TOTAL</b>	<b>3850</b>	<b>2967</b>	<b>883</b>

Predicted dust concentrations as a function of distance for various wind directions are given in Table 4 of Appendix I. These have been factored according to the dust generating capacities described above, and distances corresponding to mine-derived increments of 2 g/m<sup>2</sup>/month obtained by interpolation using the Stineman Routine. Dust vectors have been taken as originating from the respective centroids, while distances have been measured from the perimeter of the active mine area.

The factors of conservatism used in this analysis are substantial:

- Estimates of generated dust are for the most unfavourable year of operations.
- All generated dust is dispersed from the perimeter, with no allowance for attenuation within the active mine area.
- Unwatered haul roads account for some 40% of all dust, whereas dust suppression will reduce this component substantially.

### 3.0 Results

The results in terms of distances required are shown in Table 2 for both the northern and southern areas. The resulting contour is shown in Figure 1.

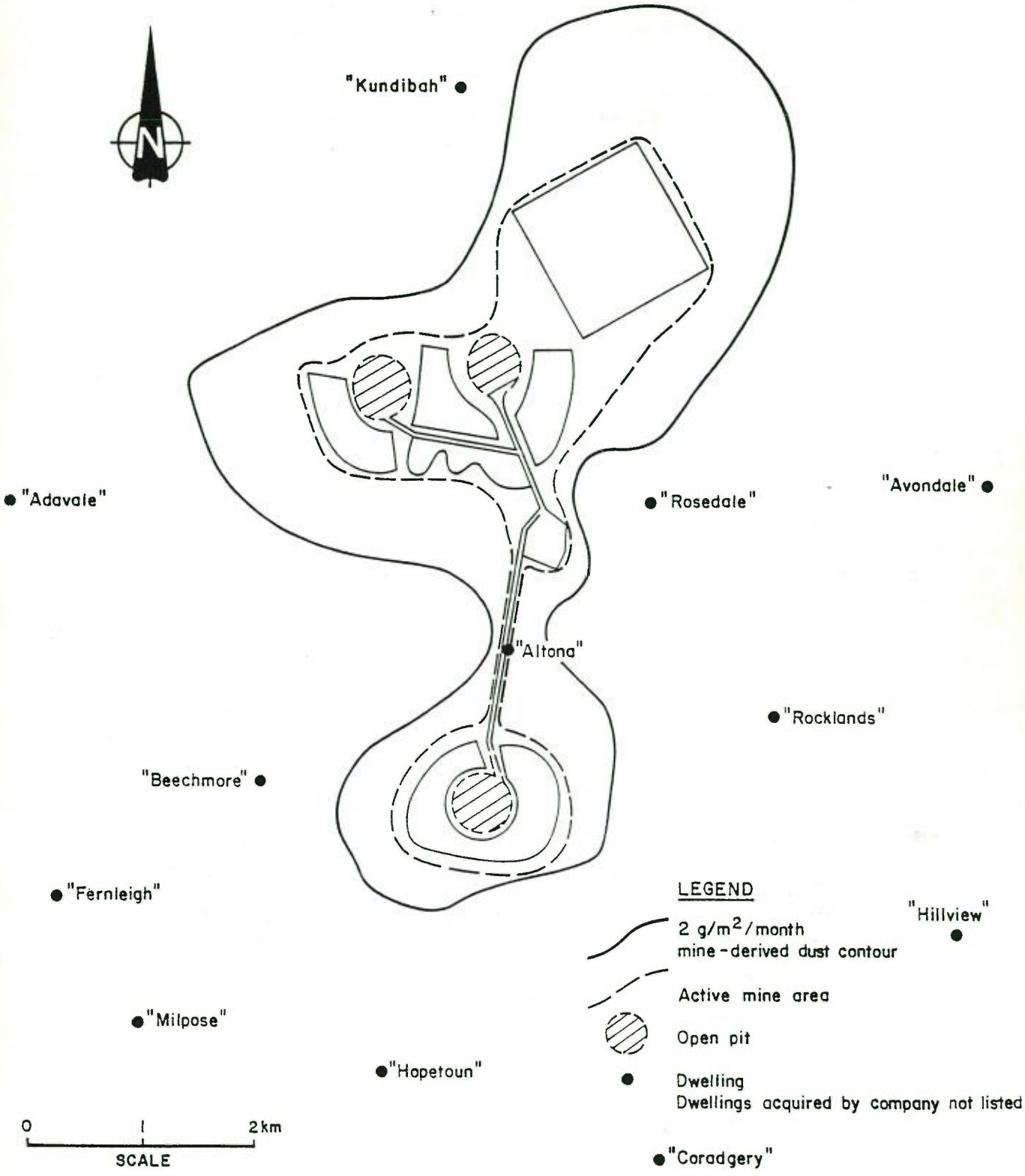
**Table 2**  
**Distances required for a 2 g/m<sup>2</sup>/month mine-derived increment**

Dust Vector	Distance from northern area	Distance from southern area
SSW	0.8	0.4
SW	0.9	0.5
WSW	0.9	0.4
W	1.0	0.5
WNW	0.7	0.4
NW	0.5	0.3
NNW	0.6	0.3
N	1.3	0.7
NNE	1.3	0.7
NE	1.2	0.6
ENE	0.9	0.4
E	0.7	0.3
ESE	0.6	0.3
SE	0.2	<0.1
SSE	0.4	0.1
S	0.4	0.1

Examination of the data in relation to five dwellings not currently owned by the company and selected for examination on the basis that they are either reasonably close to active mine areas ("Beechmore" and "Rosedale") or downwind of the prevailing directions ("Kundibah", "Altona" and "Hopetoun") shows:

- For those dwellings ("Kundibah", "Hopetoun", "Rosedale" and "Beechmore") not immediately adjacent to the mine area, the calculated mine-derived increment is less than 2 g/m<sup>2</sup>/month.
- For that dwelling ("Altona") closest to the mine area, the calculated mine-derived increment is greater than 2 g/m<sup>2</sup>/month.

The theoretical high increment at "Altona" can be attributed to its proximity (1.4 km) to the north (downwind) of the southern centroid. However, the conservative aspects of these predictions suggest that a significant dust increment at "Altona" is unlikely. During operations, dust from the haul road running past the house immediately to the east is more likely to be the source of annoyance. Localised sealing of the road may therefore be appropriate.



**NSR** NSR Environmental Consultants Pty Ltd

PEKO - WALLSEND  
NORTHPARKES PROJECT

MINE-DERIVED DUST INCREMENTS

CALCULATED 2 g/m<sup>2</sup>/MONTH  
MINE-DERIVED DUST CONTOUR

Compiled by: M.J.J.  
Date: May 1990

**Figure 1**

These results can be placed in perspective by consideration of other operating metal mines in NSW. At the Temora Gold Mine, an operation of some 1 Mt/year when dust monitoring was undertaken, comparison of dust concentrations for the pre-mining (22 months of data) and operational (20 months of data) periods showed "...no appreciable increase in the mean or seasonal deposition rates..." (Corkery 1988). Dust monitoring stations were located 1 to 2 kilometres from the active mine areas. Dust monitoring has, in fact, been discontinued at this site.

Similarly, dust levels at the Woodlawn Mine near Canberra were low at 500 m, with no mine-derived dust detectable at 1 km for an open pit mining rate of about 8 Mt/year (P. Southern, pers. comm.).

For comparison, the maximum mining rate from the E26N pit at Northparkes adopted for dust assessment is about 6 Mt/year.

## 4.0 References

Corkery (1988). Mining, Rehabilitation and Environmental Management Plan for the Temora Gold Mine. Consultant's report by R.W. Corkery & Co. Pty. Limited for the Paragon Gold Pty. Ltd.

### *Personal Communications*

P. Southern, Environmental Officer, Woodlawn Mines, Tarago, NSW.

**APPENDIX U**  
**SITE WATER MANAGEMENT SCHEME**

WLPU Consultants (Australia) Pty Ltd

Directors  
D D A Piesold B.Sc. (Eng), ENGT, M.Eng.  
P Waterhouse B.Sc. (Eng), SM, AMICE, M. ASCE  
J Waltersfield B.Sc. (Eng), ENGT, M.Eng.  
R R Knight B.Sc. (Eng), ENGT, M. ASCE, M.Eng.  
J J Burden B.Sc. (Eng), M.Eng., M. ASCE  
B S Brown B.E., Ph.D. M.Eng.

3005 Northpoint,  
100 Miller Street,  
North Sydney, N.S.W. 2060,  
Australia.

Telephone: (02) 929 5155  
Facsimile: (02) 925 0027

Ref 212.260.005  
Number 0/335

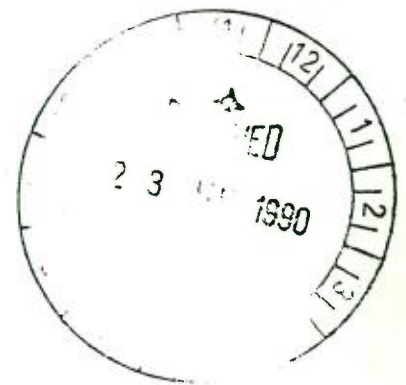
20th July, 1990

Natural Systems Research Pty. Ltd  
25 Burwood Road  
Hawthorn VIC. 3122

For attention: Mr. A. Sharp-Paul

Dear Sirs,

PARKES PROJECT  
SITE WATER MANAGEMENT SCHEME



We enclose a copy of the technical note ref. 212/A - *Site Water Management Scheme - Response to April 1990 Rainfall* as requested in your fax of 12/6/90.

The technical note provides information on the site water management scheme response to the April, 1990, rainfall using daily rainfall records obtained from the Bureau of Meteorology. For comparison of recovered volumes of water an analysis of the January rainfall is also included in the study.

Yours faithfully,  
WLPU CONSULTANTS (AUSTRALIA) PTY. LTD.

A handwritten signature in black ink, appearing to be 'JFD', written over a horizontal line.

JFD/dh

Encl.

**PARKES PROJECT  
SITE WATER MANAGEMENT SCHEME  
ASSESSMENT OF RESPONSE TO APRIL 1990 RAINFALL**

1. INTRODUCTION

The site water management scheme for the Parkes Project is designed to supplement process water supplies by providing facilities for the collection of rainfall runoff from catchments associated with the project. The designed capacity of the collection and return facilities will provide a water recovery scheme which provides the maximum benefit in terms of value of water recovered. For the high intensity events or large Average Recurrence Interval (ARI) events much of the rainfall runoff will pass through the facilities, where appropriate, as the cost of providing high capacity for infrequent rainfall events is not economic.

2. WATER RECOVERY

2.1 General

The efficiency of the site water management scheme in recovering rainfall runoff will vary according to the intensity and duration of rainfall events. Maximum runoff recovery is anticipated from the lower intensity rainfall whereas runoff recovery from intense events would not be significantly improved. To demonstrate this behaviour two recent rainfall periods (January 1990 and April 1990) have been input into the water management model and the volume of recovered water calculated.

2.2 Rainfall Data

Daily rainfall records for the months of January, 1990 and April, 1990, as recorded at the Parkes P.O. (station No. 065026) were obtained from the Bureau of Meteorology for input into the water management model. The data are presented in Table 2.1.

**Table 2.1:** Daily rainfall data

Day	January 1990 (mm)	April 1990	Day	January 1990 (mm)	April 1990
1	-	-	17	-	-
2	-	-	18	-	-
3	-	-	19	-	35.0
4	-	0.6	20	4.0	61.0
5	-	0.6	21	-	10.0
6	-	-	22	-	22.0
7	14.0	-	23	-	1.0
8	27.0	0.2	24	-	-
9	15.0	30.0	25	-	-
10	9.0	4.0	26	-	-
11	-	62.0	27	-	-
12	-	48.0	28	-	-
13	4.0	-	29	-	3.0
14	3.0	17.0	30	-	-
15	-	2.0	31	-	-
16	-	-			
1990 Monthly Total				76.0	296.4
Mean Monthly Total				61.0	41.0

## 2.3

## April 1990 Rainfall

The recorded April 1990 rainfall was 7.2 times the average April rainfall and was received over 15 days compared to an average of 5 raindays. The results of the analysis indicate that the runoff volumes and rates of inflow would be well above design capacity for the site water management facilities and especially on the 5 heaviest rainfall days in which 80% of the monthly rainfall fell, a great proportion of the rainfall runoff passed through the facilities. On the days during which less intense rainfall was recorded little or no runoff was lost.

The estimated volumes of runoff generated and estimated volumes collected during the month of April are given in Table 2.2.

**Table 2.2:** Rainfall runoff - April 1990

Catchment *	Total Runoff (m <sup>3</sup> )	Pond Spillway Discharge (m <sup>3</sup> )	Water Recovery	
			To Plant (m <sup>3</sup> )	To Tailings Facility (m <sup>3</sup> )
1	560 000	470 000	-	90 000
2	125 000	105 000	-	20 000
3	18 000	0	18 000	-
4	410 000	360 000	50 000	-
5	800 000	710 000	-	90 000
Total	1 913 000	1 645 000	68 000	200 000

\* Refer to WLPU report 212/6

Water collected from the clean and dirty classification catchments (WLPU report ref. 212/6, March 1990, Section 4.2.3) would be either returned directly to the plant or returned to the tailings facility for storage and later use. Runoff from these catchments which cannot be accommodated would be routed through the ponds, sediment removed and water discharged via the spillways on each pond.

Runoff from the catchment containing the sulphide marginal mineralisation stockpile would be collected in pond No. 3 and pumped directly to the plant. It would be necessary to immediately commence operating the pump at pond No. 3 on only two days during the April rains when 62 mm and 61 mm of rain were recorded.

#### 2.4 January 1990 Rainfall

Rainfall recorded in January 1990 was slightly above the monthly average and was recorded on 7 raindays as opposed to an average of 6 raindays for January. Most of the rainfall fell over a 4 day period with one of these days receiving 36% of the monthly rainfall.

Spillway flows from the four clean and dirty catchment ponds would occur however in all cases the flows were initiated by the heavy rainfall of 8th January followed by 15 mm the next day.

The estimated volumes of runoff generated and volume collected during January are given in Table 2.3.

**Table 2.3:** Rainfall runoff – January, 1990

Catchment *	Total Runoff (m <sup>3</sup> )	Pond Spillway Discharge (m <sup>3</sup> )	Water Recovery	
			To Plant (m <sup>3</sup> )	To Tailings Facility (m <sup>3</sup> )
1	133 000	89 000	-	44 000
2	29 000	21 000	-	8 000
3	4 300	0	4 300	-
4	97 000	71 000	26 000	-
5	182 000	148 000	-	34 000
Total	445 300	329 000	30 300	86 000

\* Refer to WLPU report 212/6

## 2.5

### Conclusion

The site water management scheme as designed would permit full recovery of rainfall runoff from the lower range of intensity events. Runoff from the higher intensity and recurrence interval events would be partially recovered with the proportion of runoff being passed through spillways increasing with the intensity of rainfall. The results of this behaviour are demonstrated by comparison of the two monthly rainfall analyses shown in Table 2.4.

**Table 2.4:** Rainfall recovery 1990

Month	Total Runoff (m <sup>3</sup> )	Water Recovery	
		(m <sup>3</sup> )	(% of Total)
January	445 300	116 300	26
April	1 913 000	268 000	14

The results of the analysis indicate that the increase in rainfall runoff recovery in April, 1990, would not be proportional to the total rainfall received. In fact the majority of the increase in runoff recovery during April as compared to January was the result of the higher number of moderate rainfall days in April as compared to January.

It was demonstrated in WLPW report ref 212/6 that it is not economic to increase the capacity of the collection and return facilities to cater for the higher intensity infrequent rainfall events or the abnormally wet years or months. Maximum water recovery will be of greatest importance for the lower intensity events when the site water facilities will be able to provide peak runoff recovery to supplement process water requirements. The higher intensity rainfall events will provide large volumes of runoff from the surface of the tailings dam and as such efficient collection from the site water management scheme would not be as critical.

### 3. INTEGRITY OF SYSTEM

#### 3.1 General

The water management facilities for the Parkes Project include the tailings storage and sulphide marginal mineralisation stockpile area and the separate catchments containing disturbed areas and non-mineralised waste dumps. The design capacity of the tailings storage and sulphide stockpile area to contain rainfall runoff without discharge provides for the accommodation of runoff from a 1/100 year wet year and also runoff from a 100 year 72 hour storm. Runoff from the other areas may be released following removal of sediment in stilling ponds.

These minimum design criteria would have been well tested by the 296 mm of rainfall received during April 1990 at Parkes. Since records were commenced in 1889 this was the heaviest April rain recorded exceeding the previous highest April rainfall of 151 mm by almost 100%.

### 3.2 Tailings Storage

Water from the tailings facility is returned to the plant via a buried pipeline running from the centre of the storage to a lined return water pond outside the tailings storage area. The flow of water into this return water pond is regulated by a float control valve which shuts off the flow from the tailings storage when water reaches a pre-determined level. For the April 1990 rainfall a considerable volume of water would be retained on the tailings.

The most critical time for containment of rainfall runoff would be if the tailings level was to the crest of the perimeter embankment. In this case a minimum possible water storage capacity would be available as provided by the inverted pyramid shape created by the tailings beaches sloping from the perimeter to the central decant tower. This minimum capacity is calculated to be  $1.4 \times 10^6 \text{ m}^3$ . Additional volume would be available as the design calls for construction of subsequent embankment stages when tailings reach a level 300 mm below the existing embankment crest. This would infer a minimum possible flood storage capacity of  $1.9 \times 10^6 \text{ m}^3$ .

Assuming an operational year during which tailings reach a level requiring construction of the next embankment lift at the time of the April 1990 rainfall, water balance calculations using the 1990 rainfall data to date show that up until April no pond would develop on the tailings. This is similar to the result achieved by adopting average climatic conditions as analysed for the design. Analysis of the response to the April rainfall indicated the necessity to store large volumes of water on the tailings. The volumes were calculated based on the following conservative assumptions:

- Average April rainfall of 41 mm occurred during April.
- An additional instantaneous rainfall input of 255.4 mm occurred.
- Runoff coefficient from the tailings was 1.0.
- All water recovered from the site water management facilities was input into the tailings storage.
- No plant usage of water from the tailings storage occurred due to the assumed short rain input time.

A total of 625 000 m<sup>3</sup> of additional water was calculated to have been input into the tailings dam made up as follows:

- 357 000 m<sup>3</sup> runoff from inside the tailings storage.
- 200 000 m<sup>3</sup> from site water management facilities to the tailings dam.
- 68 000 m<sup>3</sup> from site water management facilities diverted from the plant to the tailings dam.

The 625 000 m<sup>3</sup> is equivalent to 43% of the flood storage capacity of the tailings facility assuming no freeboard and 33% of the flood storage capacity assuming the specified minimum freeboard of 300 mm. If the rain occurred at any time other than at the maximum tailings storage for the particular embankment stage the capacity margin would be greater. The 625 000 m<sup>3</sup> of stored water would form a central pond on the tailings which would be no closer than an estimated 240 m from the perimeter wall of the tailings facility.

### 3.3 Sulphide Stockpile Catchment

Runoff from the sulphide stockpile catchment flows into stilling pond No. 3 (refer WLPV report ref. 212/6) The catchment is classified as a no release catchment for rainfall less than the design Average Recurrence Interval of 100 years after which excess volumes may pass into catchment No. 1 where flows are diluted and routed through stilling pond No. 1 for removal of sediment. Excess volumes which cannot be recovered from stilling pond No. 1 are discharged via the spillway attached to stilling pond No. 1. Stilling pond No. 3 is equipped with a pump to return water to supplement process water and this pump would be activated when a specified stilling pond No. 3 level is reached. Actuation of the pump will improve the security of the pond beyond design levels by drawing down some of the stored runoff.

Input of the April 1990 rainfall data into the stilling pond No. 3 catchment model shows that the pump would need to be activated and the maximum pumping capacity of 35 l/s would be necessary for the 12th and 21st April. These two days each follow the two heaviest rainfall days in April. Maximum pond storage requirements with the pump operating would be 2 900 m<sup>3</sup> or 83% of the pond below ground capacity.

### 3.4 Other Catchments

Remaining catchments are classified as suitable for water release following removal of sediment. Water would be passed through stilling ponds to enable the removal of suspended sediment and the water then either pumped to the tailings storage or discharged via spillways attached to each pond. Most of the runoff would be discharged in the same manner as farm dams operated during the April 1990 rainfall.

### 3.5 Aerial Flooding

Following the heavy falls in late April an aerial reconnaissance of the area was flown to examine the extent of the flooding. Oblique aerial photographs taken on the flight show that the project area was free from inundation at a time when extensive flooding was being experienced in other areas of the region.

The lowest lying point in the project area, where the centre of the northeast embankment of the tailings facility will be, was also seen to be free from inundation.

### 3.6 Conclusion

The assessment has shown that the extreme April 1990 rainfall received in the Parkes area would not have resulted in embankment overtopping or any problems necessitating emergency release of contaminated water from the Parkes Copper Gold Project tailings facility or stilling pond No. 3. Considerable volumes of runoff from the non-mineralised waste dumps and associated catchment areas would spill from the stilling ponds where permissible as the design capacity of these facilities is not sufficient to contain such large volumes. Water leaving these catchments would be routed through the stilling ponds and have sediment removed prior to discharge.

PEKO-WALLSEND OPERATIONS

EIS

824

Northparkes project : final  
environmental impact statement

Vol 2

L borrower's name

Date

E

EIS 824



PEKO-WALLSEND OPERATIONS

Northparkes project : final  
environmental impact statement

EIS  
824  
Vol 2